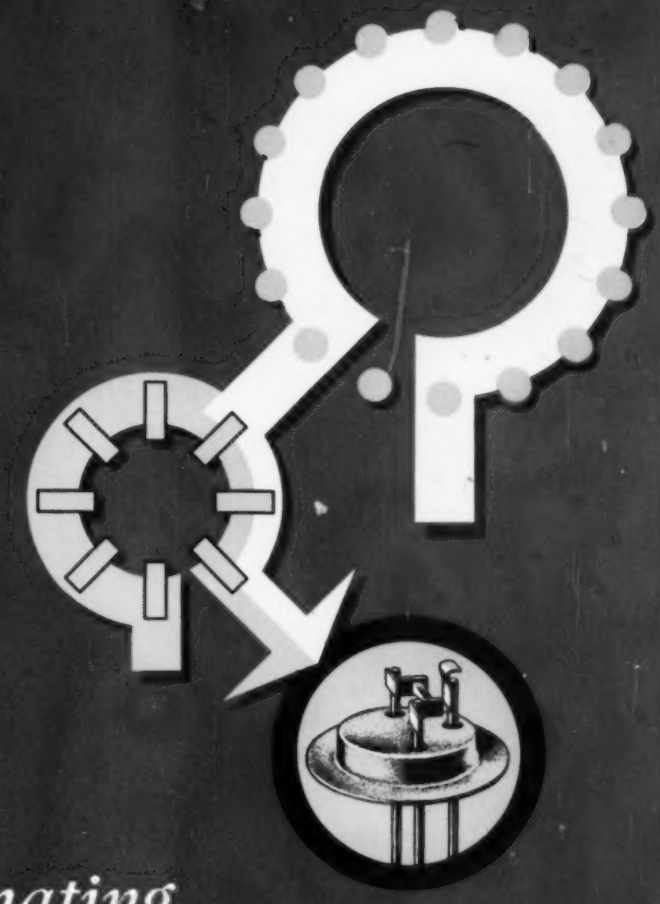
AUTOMATION

FEBRUARY 1960



Automating Transistor Assembly

THE MAGAZINE OF AUTOMATIC MANUFACTURING OPERATIONS

- **Electrohydraulic Servo Systems**
- **Handling Pistons Automatically**
- **Controls for Automated Pressworking**
- **Integrated Rod Drawing**

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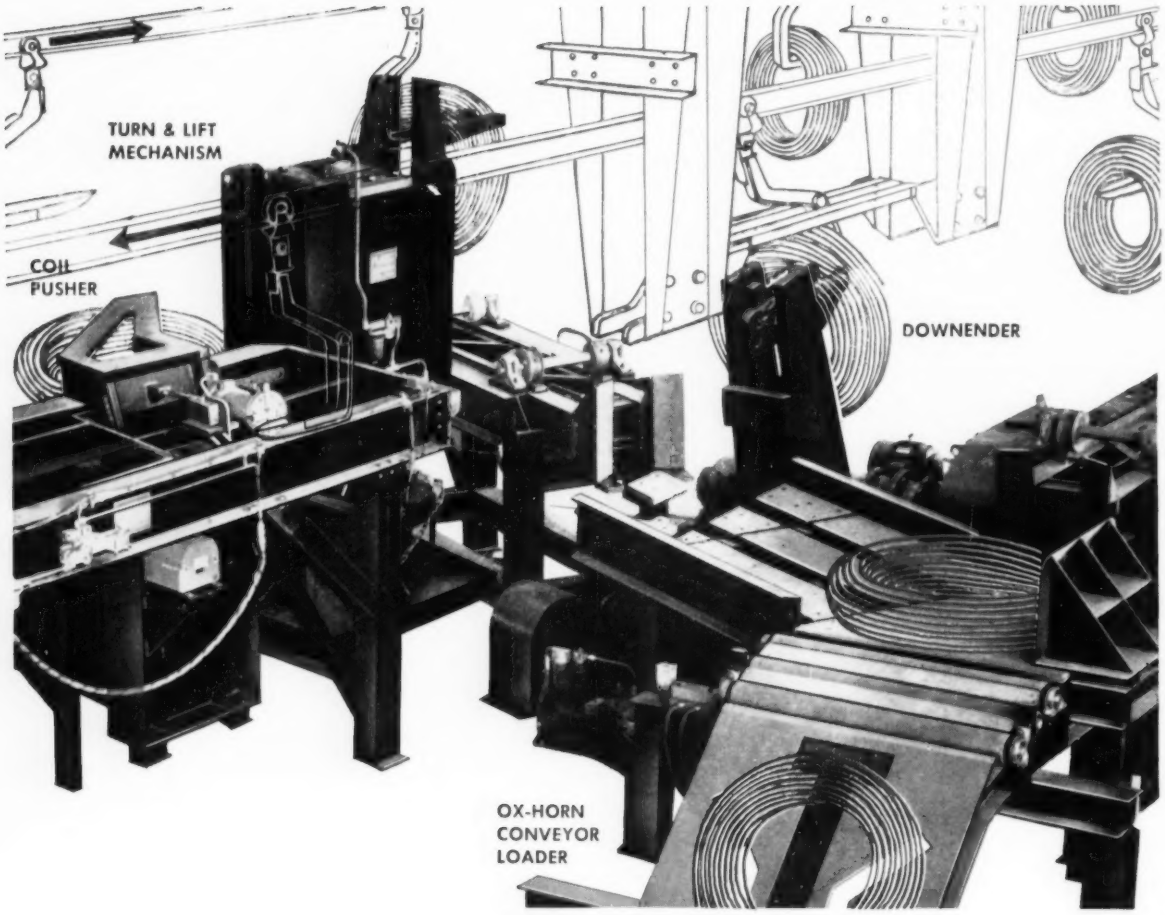
A PENTON PUBLICATION



another example of Planet Versatility...

COIL HANDLING SYSTEM LOADS AND UNLOADS EXISTING CONVEYORS AUTOMATICALLY

This automatic coil handling system is an example of how *Planet Versatility* helped one of America's largest steel mills modernize its 10-inch bar mill to handle larger, 2000-pound bar coils . . . and save money by designing the coil handling equipment to load and unload *existing* conveyors.

A red-hot, 2000-pound bar coil is transferred from an existing drag-chain conveyor to the automatic trolley conveyor loader by a single arm coil pusher. The coil pusher deposits the coil on a drop table which, when lowered, leaves the coil hanging on one arm of a turn and lift mechanism. As this machine revolves 180 degrees it lifts the coil into position to be engaged by a trolley conveyor hook and, at the same time, lowers its other arm to receive the next coil. After cooling on the existing trolley conveyor, a downender removes the coil and sets it on a slider bed on which it is indexed into a banding position. The coil is then transferred onto an existing ox-horn conveyor. *The entire system operates on a 15-second cycle and is completely automatic.*

This automatic coil handling system is more evidence of Planet's versatility . . . its ability to engineer, manufacture, and erect automated systems which solve the most perplexing production, materials handling, and automation problems. Planet has automated production lines, built bulk and unit materials handling systems, designed and erected complete plants . . . and Planet systems are found in the plants of leading manufacturers in almost every industrial classification.

Write or phone to have a Planet engineer demonstration how "PV" can help you . . . you'll find *it pays to plan with Planet.*

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CORPORATION

* Engineered Handling Systems
* Automation Equipment
* Mill & Foundry Handling Equipment

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LANSING, MICHIGAN

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912

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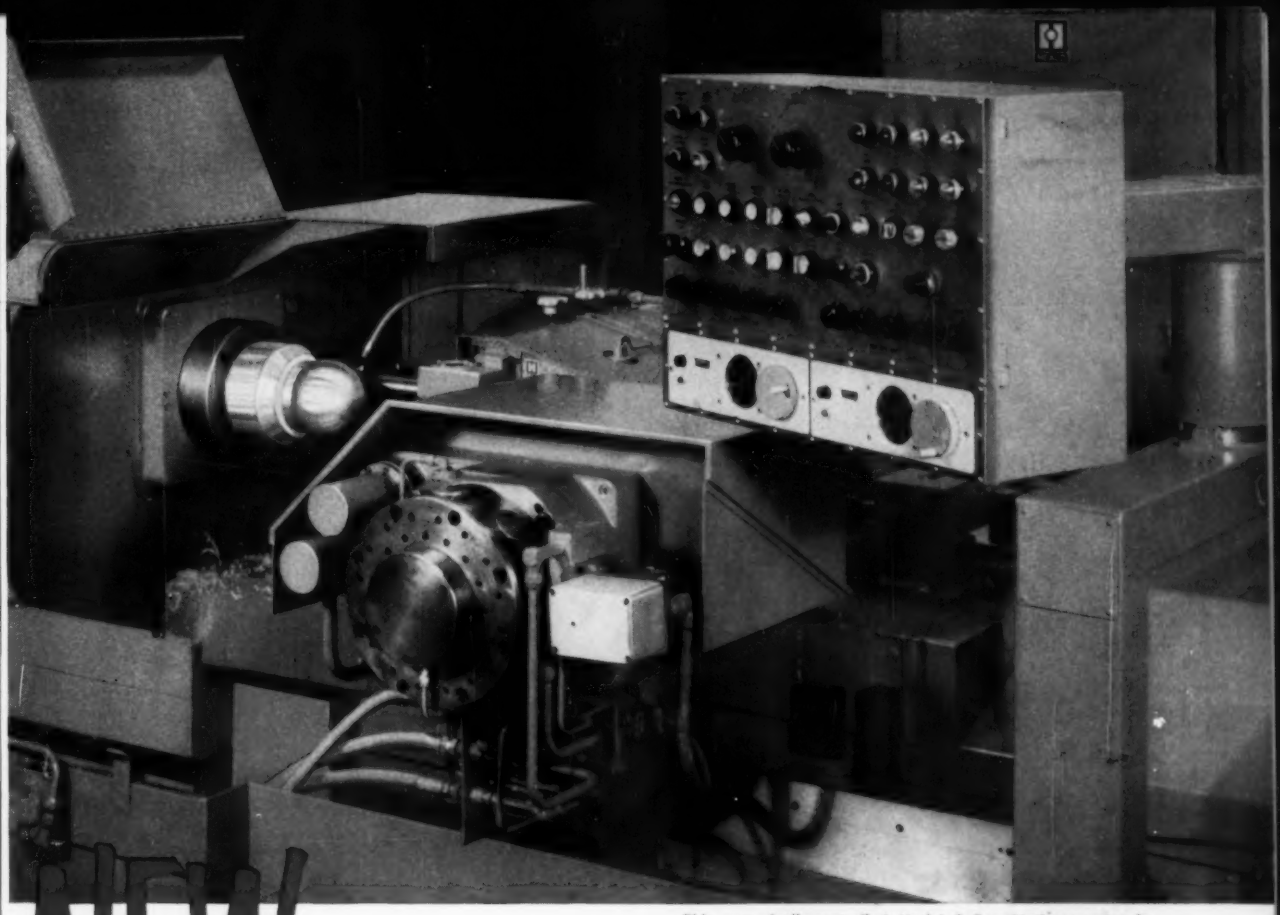

This numerically-controlled Model S Bore-Matic operates in an air-conditioned, temperature-stabilized cubicle to maintain the extremely high precision of which the machine is capable.

NEW TAPE-CONTROLLED BORE-MATICS

precision bore and turn free contours to ±.0001"

ON THE NEW, numerically-controlled Heald Model S Bore-Matics, free-form shaped parts are borized in production with a heretofore unattainable degree of accuracy and precision. Tool motion and work speed are automatically controlled throughout the entire cycle, in increments so small that contours are generated with a dimensional tolerance of ± .0001". These Model S machines have been supplied in several sizes, with various types of numerical control, and are now in successful operation on a number of classified projects.

The machine shown above, with 20" table stroke and 15" cross slide travel, is arranged for punched tape control using Cincinnati Milling Machine Company's Acramatic system. Table and cross slide are actuated by preloaded, re-circulating ball nut precision lead screws with hydraulic motor drive. Pressure lubricated box-type ways track to an accuracy of 25 millionths in 20 inches of travel. The specially designed work spindle turns within 30 millionths for total runout, and is driven by a cam-controlled variable speed unit arranged to maintain the proper cutting speeds for any given point on the workpiece contour.

For further details on numerically-controlled Model S Bore-Matics, contact your Heald engineer or write to The Heald Machine Company, Worcester, Mass.

It PAYS to come to Heald

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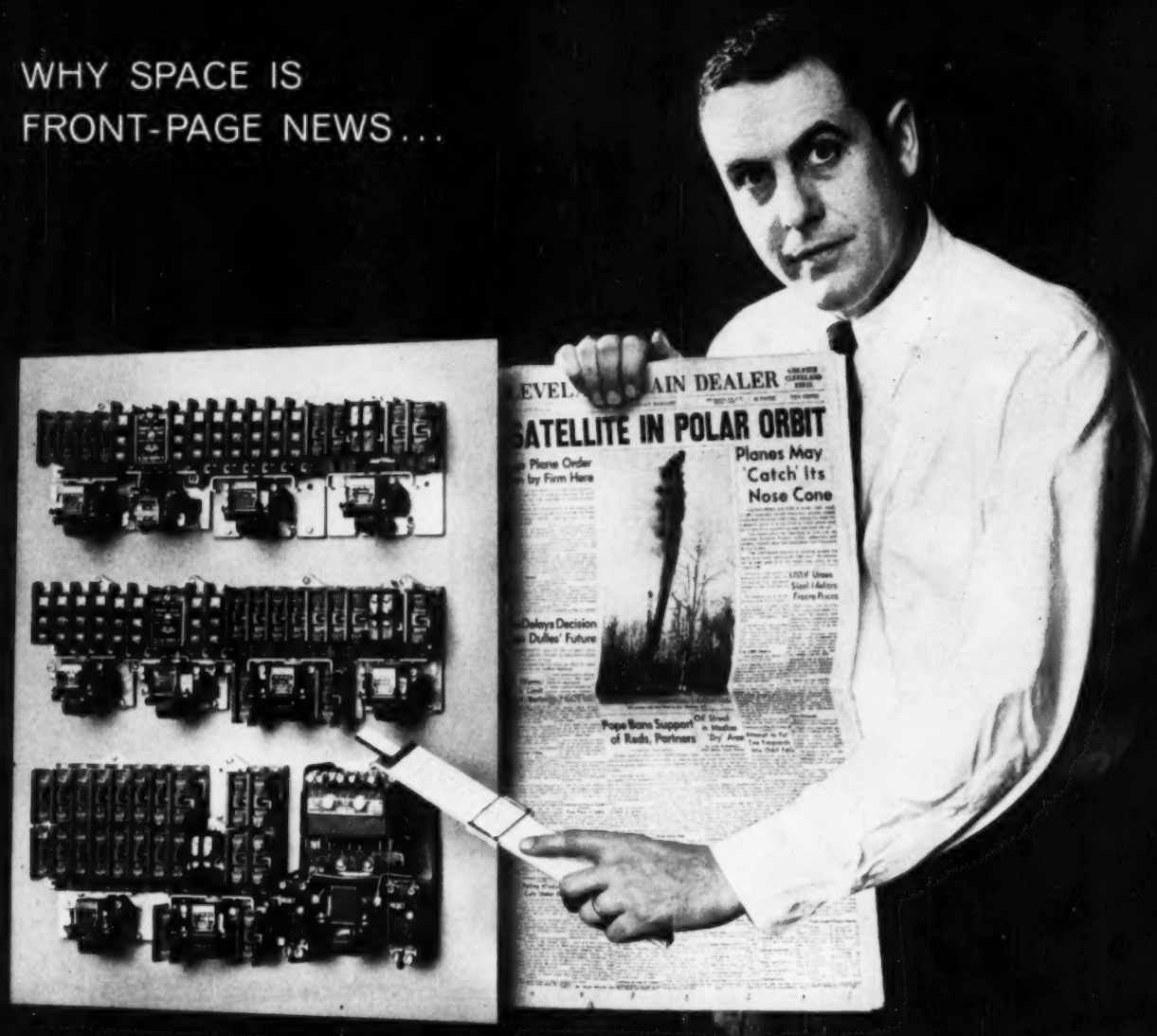
WHY SPACE IS
FRONT-PAGE NEWS...



Compact Clark Relays control 72 circuits from panel area smaller than a newspaper

In this day of space exploration and space economy, it's news—front page news—when you can get 72 separate, controlled circuits all on a panel no larger than 15" x 20".

Clark Controller, with the most complete and integrated line of control relays available today—convertible pole, latch, universal pole, and time delay—does it! And only Clark offers such a wide range of operation, so many contacts, in a panel area of such small size.

Shown mounted here with the Clark Size 1, Type "CY" Starter are 10 compact Clark Relays which include four time delay contacts (two normally open, two normally closed), 52 instantaneous contacts (14 normally open, 14 normally closed, and 24 convertible), plus 16 latching contacts (all convertible).

The same engineering leadership and superior workmanship that made Clark Controller the *standard of quality* for controls in heavy industry, is inherent in the broad line of Clark Relays for modern panels.

The "modular construction" of all Clark "PM" Relays insures integrated uniformity, compactness and flexibility. Functional alignment in mounting results in neater, more uniform panels and most efficient utilization of valuable space. And because "PM" relays are available in a wide variety of pole combinations, providing up to 14 contacts on a single relay, you can control more circuits—save on relay requirements.

For more information on the complete line of Clark "PM" Relays which is making space-saving headlines, contact your nearest Clark Controller sales office or distributor. Or, write direct to Clark Controller for free bulletins.

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The CLARK CONTROLLER Company

Everything Under Control • 1146 E. 152nd St. • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

FEBRUARY 1960
Vol. 7 — No. 2

AUTOMATION®

A PENTON PUBLICATION

The Magazine of Automatic Manufacturing Operations

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automation outlook

MARKET EXPANDED BY AUTOMATED PRODUCTION

". . . Still broader applications of transistor technology are limited to a large extent by the volume in which transistors can be economically produced. As in any other manufacturing operation, manual techniques are not conducive to production at high volumes and low cost. Therefore, several months after Western Electric assembled its first "production line" transistors in 1951, an Engineering Development Group was formed for the express purpose of investigating manufacturing processes and developing facilities. . . . One project undertaken by this group was the development of a machine to automatically assemble grown junction NPN transistors. . ."—*R. C. Shafer, department chief, Thermistor, Mercury Relay and Switch Dept., Western Electric Co. Inc.*, *see page 83.*

RETURN OF FIVE FOR ONE

". . . I am happy to say that Standard Oil Co. (N. J.) has long recognized the importance of research and technology . . . We regard our expenditures in this area as a sound investment in the future, an investment which keeps our operating affiliates at once competitive and progressive . . . Our experience in the past has been that every dollar spent to develop new products and improve technology earns approximately five dollars in return . . ."—*M. W. Boyer, director, Standard Oil Co. (N. J.)*

SERVO CONTROLS—DIRECTLY USABLE

". . . Electrohydraulic control systems combine the speed, sensitivity, and adaptability of electronics with the force-exerting capabilities and flexibility of application of hydraulics. The state-of-art level in both technologies—electronics and hydraulics—is such that standard components are directly usable in most industrial servo control systems. . ."—*R. L. Fillmore, manager, Machine Controls Products Dept., Minneapolis-Honeywell Regulator Co.*, *see page 56.*

LINKING PRODUCTION AND MARKETING

". . . Automation is more than the substitution of machine power for muscle power. It carries with it the profound notion that man may delegate to machines certain limited types of decisions, including the technique of continuous sampling by sensing devices. This promises to provide the flexibility to change any or all phases of a process as a result of machine analysis and control. Eventually we will find that automatic electronic devices will link production and marketing. . ."—*A. V. Astin, National Bureau of Standards.*

REDUCING PRODUCT PRICES

". . . mechanized production techniques, along with new device developments, will significantly lower manufacturing and production costs within the next decade, and these savings and improvements will be passed on to the customer . . . As a case in point, within the last four years the average price of silicon transistors was lowered 60 per cent, and as mechanized production techniques are developed and as the manufacturing volume increases, this downward unit price trend will continue . . ."—*M. Shepherd Jr., vice president, Texas Instruments Inc.*

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BPA NBP

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. . . Fluid Power news

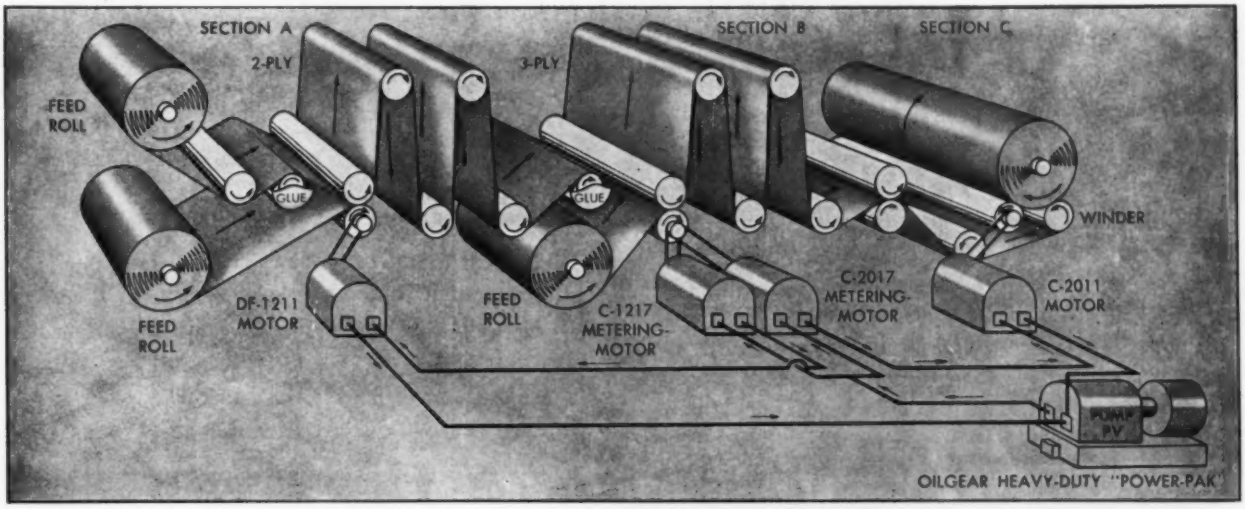
REPORT NO. 12,101
FAST-ACTING MULTI-STAGE DRIVE

From Oilgear Application-Engineering Files

HOW OILGEAR "*ANY-SPEED*" DRIVES SIMPLIFIED MODERNIZATION OF A LAMINATOR

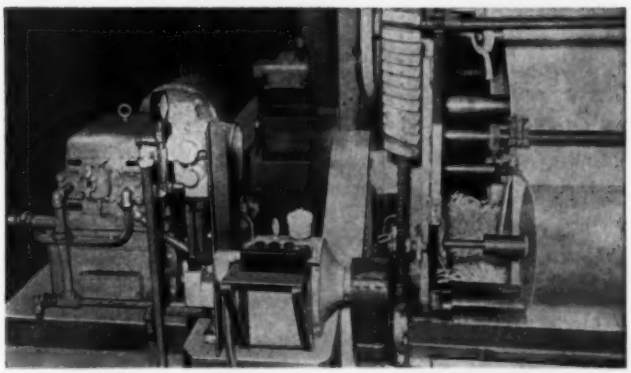
CUSTOMER: *A Large Midwestern Paper Manufacturer*

DATA: This company initiated an extensive equipment modernization program to enable expansion in competitive fields, and increase production efficiency. Part of this program consisted of adding a new section to an Oilgear-powered laminator and winder. *Requirements:* 1: Maintain proportional synchronization and power coordination between existing section and winder with new section. 2: Fast-acting controls for individual, precision, sectional speed adjustments. 3: Start, stop, change speeds rapidly, and run at *any* selected speed to maximum without tearing paper web. 4: Accurate, adjustable, automatic winder tension control. 5: Complete conversion in minimum of machine "downtime." 6: Selected drive must be thrifty on floor space and electrical power.



SOLUTION: Shown above schematically with new section A to left. Oilgear Heavy-Duty, *"Any-Speed"* drives were selected for this application primarily because of space savings, ease and speed of conversion, and long experience with Oilgear's *low-cost-per-year* operational record in their plants. Unusual application feature is the use of a single, Oilgear Size 35 "Power-Pak" as the Fluid Power source for all three exactly coordinated sections of this multi-stage machine. *Performance has proved superior to requested specifications — with no reported maintenance after more than two years of continuous, high-speed service.*

OPERATION: Oilgear type "DE" Variable Displacement Pump (PV) — accurately, remote pushbutton station controlled from zero to maximum output — drives two Oilgear type "C" fixed stroke, constant torque, radial piston motors (C-1217, C-2017). Acting as tandem motors, they power section B. They also act as meters for motors (DF-1211, C-2011) connected in series with them. Oilgear type "DF" variable stroke, constant hp, radial piston motor (DF-1211) powers new section A in series with section B motor (C-1217). Oilgear type "C" motor (C-2011) powers section C in series with section B motor (C-2017). Speed changes initiated from control station pushbuttons to Pump (PV), are imparted to section B, and proportionally to sections A and C. Proportional speed relationship between sections A and B is easily altered by stroke adjustment of motor (DF-1211). Speed relationship between sections B and C is automatically altered as roll diameter increases by an automatic winder tension valve. Maximum torque in section A is independently adjustable. Solenoid-operated brake valves insure rapid, cushioned stops. Rapid, cushioned starts are an inherent feature of Oilgear *"Any-Speed"* drives. This completely sealed, compact, fully pressure lubricated, *"Controlled-Motion System* delivers full rated torque at *"Any-Speed"* . . . automatically conserves electric power . . . quiet, vibration and trouble-free.



View from winder end of laminating machine after a "rush" conversion, completed and running without trouble ahead of schedule. Oilgear Heavy-Duty, Size 35 "Power-Pak" can be seen in left foreground. One pushbutton control station and winder tension valve are to left and in front of series driven, Oilgear type "C" motor which powers the winder section. Oilgear "C-2017" meter, one of the tandem drive metering-motors on the center section, can be seen in center background.

Because of Oilgear's long reputation for cooperative teamwork in solving drive problems with dependable, trouble-free Fluid Power Systems for virtually any application — Oilgear has become a name that all industry trusts . . . and uses.

For similar practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

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Application-Engineered Controlled Motion Systems

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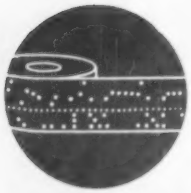
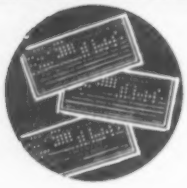


CINCINNATI ACRAMATIC...



complete integration of numerical control and machine design

Here is a simplified numerical control system that brings to more and more shops the cost-saving benefits of this efficient manufacturing concept. This system realizes the full potential of numerical control because all its elements are completely coordinated from their inception under the single responsibility of The Cincinnati Milling Machine Co. . . . where numerical control specialists work hand in hand with machine tool designers, and application and methods engineers.

ACRAMATIC is a simpler, more adaptable system for either positioning or contouring, with a number of practical advantages that reduce the time and cost of both programming and machining . . .

Simplified Contour Programming, requiring less input data because of exclusive parabolic interpolation method.

Cutting Tool Compensation permits change of cutters without change in programming.

Zero Shift Control eliminates need for exact positioning of work on table.

Automatic Repositioning — all dimensions are established from a single base point.

Feed Rate Override allows manual adjustment of feeds below programmed rates.

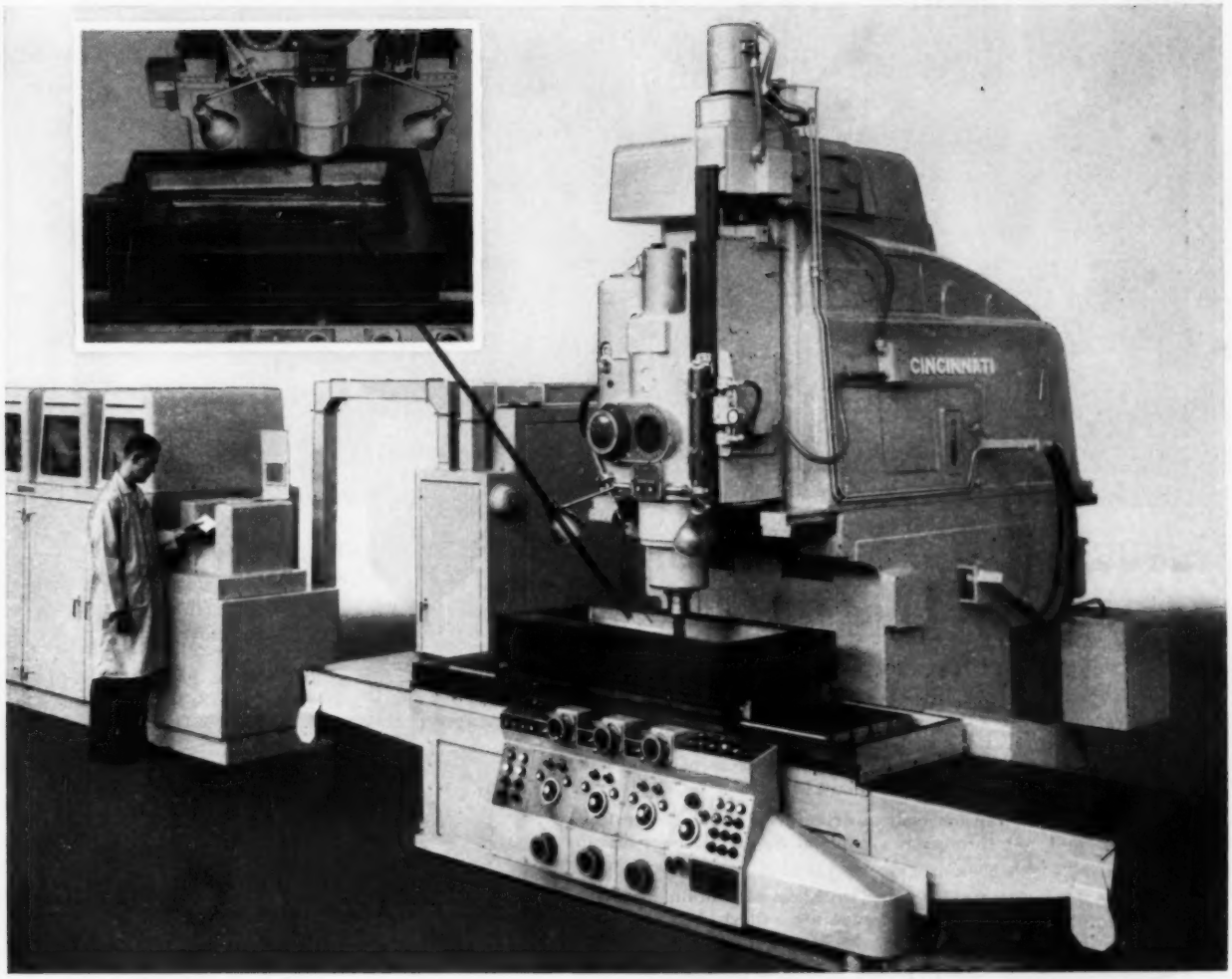
Accuracy unaffected by varying line voltages, because dimensions are represented by voltage ratios.

There are many other ways in which CINCINNATI ACRAMATIC takes full advantage of the possibilities of numerical control. General information is contained in Publication M-2125, or our Application Engineers will be glad to show you how this unique system can be applied in your shop. May we hear from you?

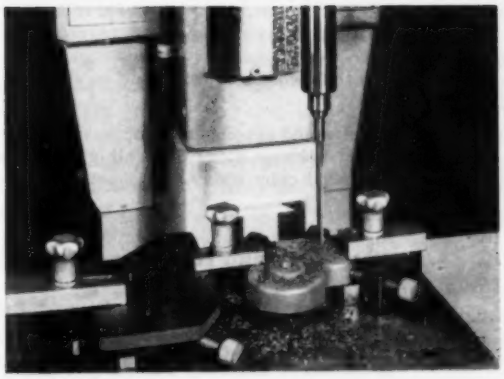
The Cincinnati Milling Machine Co.
Cincinnati 9, Ohio

CINCINNATI

BUILDERS OF FINE MACHINE TOOLS: MILLING • GRINDING • BROACHING • ELECTRICAL DISCHARGE MACHINING • DIE SINKING • CUTTER AND TOOL GRINDING • PRODUCTION LINES • METAL FORMING • • HARDENING MACHINES



Above: CINCINNATI 30" x 52" Vertical Hydro-Tel equipped with CINCINNATI ACRAMATIC 3-Axis contour control, performing a die sinking operation on a die for a milling machine motor compartment cover. ACRAMATIC's exclusive parabolic interpolation method programmed this entire complex operation using only 2000 punched cards for the twenty hours of machining required.



At right: CINCINNATI ACRAMATIC 2-Axis Positioning Control automatically provides fast, accurate hole location. Programming requires only the typing of an eight-digit number for each hole location.

CINCINNATI®

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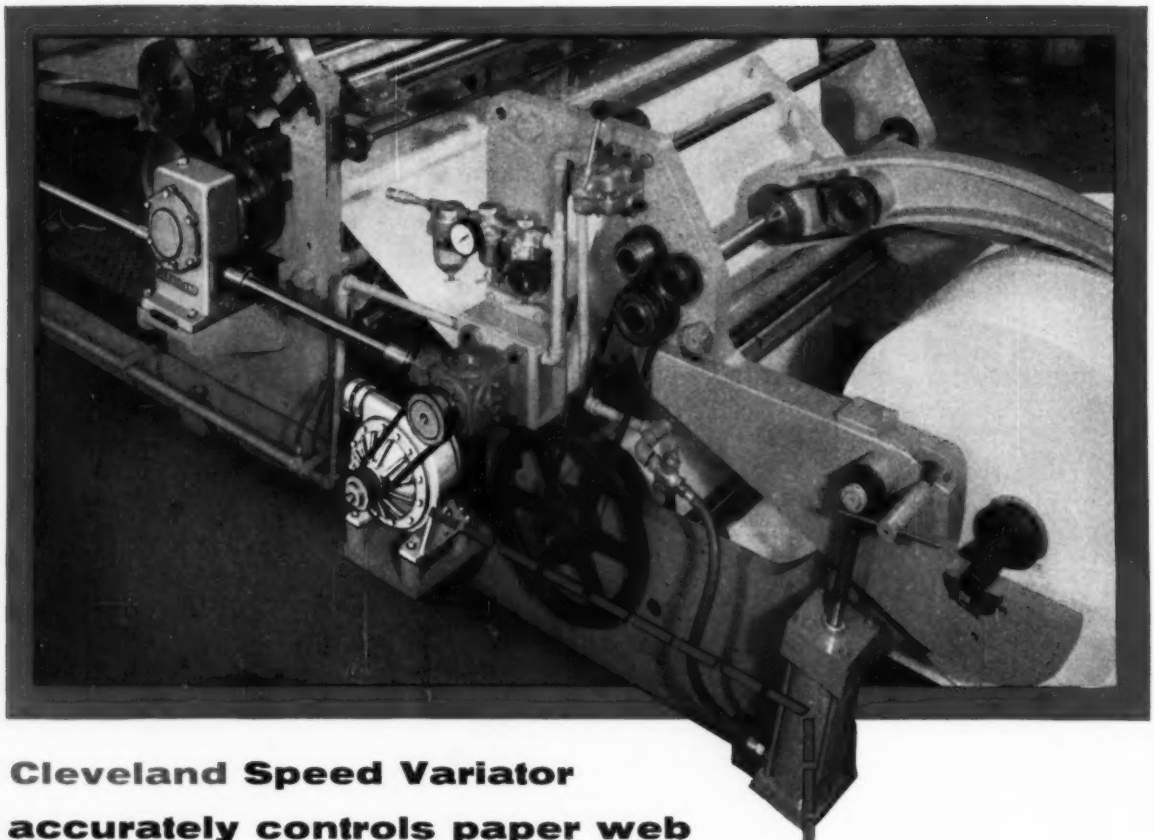


Cleveland Speed Variator accurately controls paper web fed into Schriber Printing Press

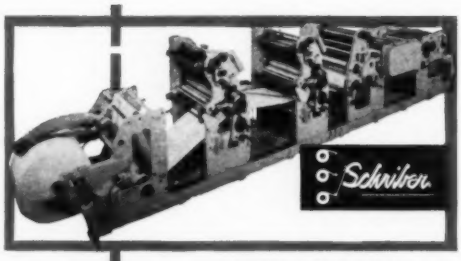
This new Rotary Offset Business Forms Press built by Schriber Press Company of Dayton, Ohio, was designed to provide printers with more hourly impressions—more daily output.

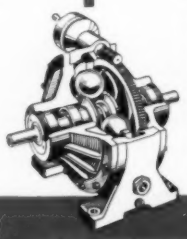
Its new infeed web tension control drive gives absolute constant tension from mill roll through a Cleveland Speed Variator-driven metering cylinder to press.

The Variator compensates for paper thickness—maintains constant surface speed of paper to the press—guarantees finished printing will always stay "in register".

A modified Cleveland Speed Variator providing increased precision within a limited (± 25%) range was selected for this important function. This was accomplished by changing the curve of Variator's iris plate. Thus, this Variator allows exacting adjustment for paper machine tension—holds that tension or can easily be changed to another speed setting.

If your operations demand speed variation, be sure to get the complete "Cleveland Speed Variator Story". It's all in free Bulletin K-200 —write for your personal copy today.





HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, left).

The Cleveland Worm and Gear Company
Speed Variator Division
3265 East 80th Street, Cleveland 4, Ohio

A subsidiary of
Eaton Manufacturing Company

Sales Representatives in all major industrial markets
In Canada—Peacock Brothers Limited

CLEVELAND SPEED VARIATOR

Circle 658 on Page 19

AUTOMATION news

Today's events and developments in the field of automation

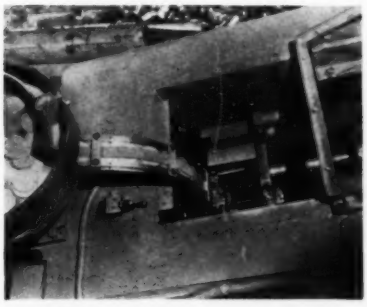
Press Development Spurs Manufacture of Aluminum Cans

ALUMINUM impact extrusion press developed by the Container Machinery Div., E. W. Bliss Co., produces 11-ounce beer cans at a rate of 120 per minute. Production rate is said to be twice that attainable with the fastest aluminum extrusion presses currently in use for can manufacture.

In operation, type 2S aluminum slugs, 2½ inches in diameter by ⅛ inch thick, are fed on tracks from the bowl of a vibratory feeder to an extrusion die. Release of slugs to the die is synchronized with the press stroke by a direct connection to the press drive. Extruded cans, 2½ inches in diameter by 5½ inches long, are ejected automatically from the die to a receiving bin. The feeding and ejecting systems were custom-designed by Bliss Co. engineers for use with the press.

Aluminum International Inc., a jointly owned subsidiary of Adolph Coors Co. and Beatrice Foods Inc., authorized the development of the press as a part of a $3.5 million program aimed at automating the production of impact-extruded aluminum cans at the Coors brewery (See AUTOMATION, March 1959, pp. 42-45).

BUYER and builder representatives are shown examining impact extrusion press that produces aluminum beer cans from slugs at a rate of 120 per minute. Developed by E. W. Bliss Co. for Aluminum International Inc., two presses of the type shown are slated for use in an automated can-making line at Adolph Coors Co. brewery.



CLOSE-UP of die area of impact extrusion press shows slugs being fed on tracks from bowl of vibratory feeder. Feeding of slugs to die is synchronized with press stroke by a direct connection to press drive.

According to **Jack Porterfield**, chief engineer of Aluminum International, integration of two of the new presses with continuous strip casting equipment previously developed by his company will make production of aluminum sanitary cans fully competitive with that of conventional three-piece steel cans.

The press is a straight side, single action, 400-ton unit inclined 13 degrees from the horizontal. Equipped with a variable speed drive motor, it can be operated at any speed between 40 and 120 strokes per minute. In a recent demonstration at the Bliss plant, more than 100 representatives of the food packing, can and container making, and metalworking industries saw the press in operation at its top speed.

To attain the relatively high production rate of the new press, the knuckle-joint action usually employed in conventional impact extrusion presses was abandoned in favor of an eccentric crank drive. Although knuckle-joint drives are capable of exerting tremendous pressing forces, they are also characterized by relatively long dwell times with the plunger advanced. Thus, to attain high output with a knuckle-joint drive, the approach and return strokes must be rapid. This introduces the problem of developing feeding and ejecting systems capable of operating in the short time available when the plunger is retracted. To avoid difficulties of this nature, Bliss engineers designed an eccentric crank drive that provides sufficient impact

speed and yet allows time for the feeding and ejecting systems to function.

A byproduct advantage of can manufacture by the impact extrusion process is that raw material shipping costs and storage space may be reduced, since it is necessary to transport and handle only small slugs occupying relatively little volume.

System Records Defects In Tinplate Coils

SYSTEM that automatically accumulates, records, and prints quality control data relating to tinplate coils has been developed by Airborne Instruments Laboratory, Div., Cutler-Hammer Inc. By means of the system, a printed record of the locations of various types of defects can be provided for each coil produced on a tinning line. Defects can be bracketed in 10-foot increments within each coil.

In an installation on an electrotinning line at Inland Steel Co., the system receives inputs from existing sensors, footage counters, and electrical controls. Additional inputs can originate from a manual input cabinet at a visual inspection station.

When a coil is entered in the line, a visual inspection operator sets knobs on the manual input cabinet to indicate the date, shift, crew, coil order number, temper base weight, line operation, and strip width. This information, and the time of the entry, are automatically typed on a preprinted form in an output cabinet.

The visual inspection station is located at the end of the tinning line near a shear that separates finished coils. When the operator observes a defect in the strip passing the station, he presses a button on the manual input cabinet identifying that type of fault. The button is held depressed until the defect is no longer observed in the strip.

Signals from the manual input cabinet and the sensors are processed in a main cabinet that contains logic plates and magnetostric-

Fourth Conference on Manufacturing Automation

Monday, Tuesday, and Wednesday

April 11, 12, and 13, 1960

Purdue University, Lafayette, Indiana

• • •

CONFERENCE TOPICS AND SPEAKERS

Engineering Costs—Who Pays? (Automation Panel)

BUYERS

K. C. **BUTTERFIELD**, Staff Master Mechanic, Chrysler Corp.
W. W. **KUYPER**, Manager, Manufacturing Engineering, Large Steam-Turbine Generator Dept., General Electric Co.
R. L. **SCHOENBERGER**, Manager, Production Engineering Dept., R. R. Donnelley & Sons Co.
W. A. **STADTLER**, Director of Manufacturing Research, International Business Machines Corp.

SELLERS

J. R. **BAREFOOT**, President, Federal Machine & Welder Co.
LEO **GAJDA**, Vice President, Snyder Corp.
E. **McFERREN**, Vice President-Sales, Giddings & Lewis Machine Tool Co.
W. K. **STOKES**, Vice President-Sales, Alvey Ferguson Co.

Manufacturing Research and Automation

T. R. **BUNNELL**, Manager of Manufacturing Services, Semiconductor Div., Sylvania Electric Products Inc.

Getting a Grip on Costs and Payoff

K. H. **MEYER**, Manager, Manufacturing Services, Reliance Electric & Engineering Co.

Organizing to Reduce Costs Through Automation

C. D. **EVANS**, Ass't. Manager, Manufacturing Research, International Harvester Co.

Process Analysis and Machine Procurement

H. A. **LEONE**, Manager, Headquarters Manufacturing Laboratory, Westinghouse Electric Corp.

Automating Assembly

C. H. **STANDISH**, President, Designers for Industry Inc.

Integrating the Packaging Operation

WILLIAM **WOOD**, President, Processes Research Inc.

Techniques for Parts Handling

R. H. **BONNER**, Application Engr., Industrial & Machine Tool Operations, Radio Corp. of America

Dispensing Problem Materials in Process

L. E. **HARPER**, President, Omega Machine Co. Div., B-I-F Industries Inc.

Mechanization for Distribution

E. J. **HARDY**, Ass't. Supt., Engineering Equipment Development, Western Electric Co.

Temperature Controls

H. G. **PAYNE**, Manager, Measurement Group Sales Product Div., Foxboro Co.

Using Relay Control Effectively

ZEKE **SMITH**, Vice President & Tech. Dir., Potter & Brumfield Div., American Machine & Foundry Co.

Doing the Job with Photoelectrics

J. J. **LAREW**, Product Engr., Specialty Control Dept., General Electric Co.

LUNCHEON AND BANQUET TOPICS AND SPEAKERS

Pioneering in Automation

WILLIAM C. **LEONE**, Vice President & Gen'l. Mgr., Rheem Califone Corp.

You and MEC

F. I. **ELLIN**, Chief Production Engr., Ohmite Mfg. Co.

A Look Into Tomorrow

JOSEPH **HARRINGTON Jr.**, Head, Mechanical Engineering Section, Arthur D. Little Inc.

Don't Give Up

ROBERT **MOORE**, President, Moore Equipment Co.

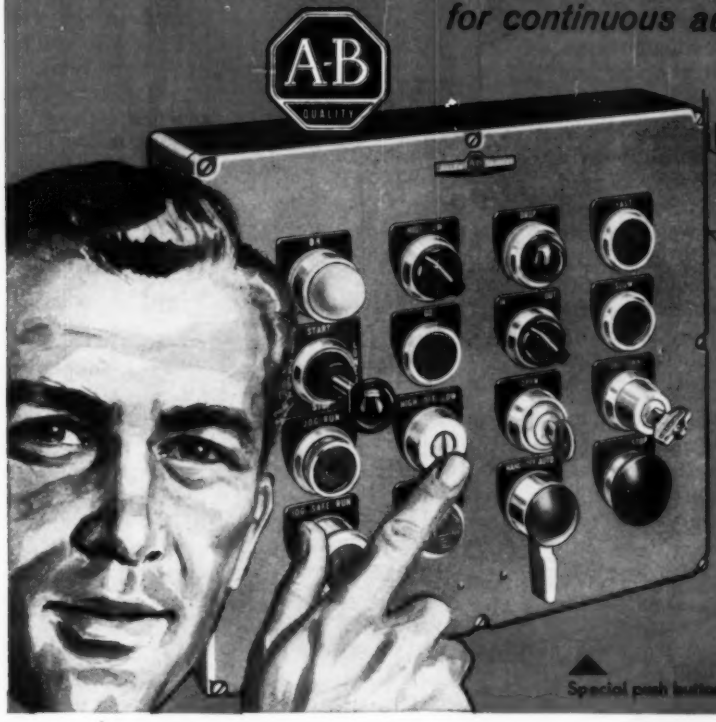
The Inevitability of Automation

H. A. **STRICKLAND Jr.**, Vice President & Gen'l. Mgr., Industrial Electronics Div., General Electric Co.

As in past conferences, informal discussion groups will be set up where automation authorities will be available to answer specific questions and exchange experiences. Exhibits of automation components and systems have also been arranged. The Fourth Conference on Manufacturing Automation is co-sponsored by Purdue University and AUTOMATION magazine. For additional information contact K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind., or AUTOMATION, Penton Bldg., Cleveland 13, Ohio.

AUTOMATION BEGINS HERE

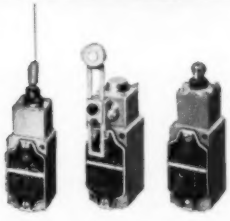
. . . Insist on Allen-Bradley accessories for continuous automatic production



In this broad line of Allen-Bradley accessories, each and every unit carries the traditional A-B trademark of *quality* that stands for trouble free operation. Rugged construction, and maintenance free, silver alloy contacts provide the reliability that is essential to the continuous operation of *your* automatic production machines.

Profit from the experience of the leading machine tool builders . . . insist on Allen-Bradley *quality* motor control *all the way!*

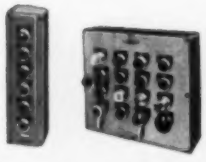
Special push button panels can be assembled to your specifications.



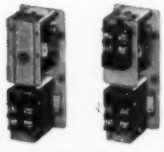
OILTIGHT LIMIT SWITCH
Bulletin 802T with sealed heads and bodies. Various operators.

PRECISION LIMIT SWITCH
Bulletin 802 oiltight. Responds to very small operator travel.

OILTIGHT CONTROL UNITS
Bulletin 800T. Choice of push buttons, lights, and switches.



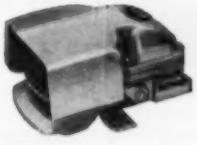
OILTIGHT CONTROL STATIONS
Bulletin 800T for up to 16 units in die cast aluminum enclosure.



PNEUMATIC TIMERS
Bulletin 849. Reliable and accurate. For on-delay or off-delay.

OILTIGHT PRESSURE CONTROL
Bulletin 836. For hydraulic systems with pressures to 5000 psi.

STANDARD DUTY PUSH BUTTONS
Bulletin 800. Up to three units, also pilot lights and switches.



FOOT SWITCH
Bulletin 805. In rugged die cast housing for toughest service.

ALLEN-BRADLEY
Member of NEMA

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1339 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

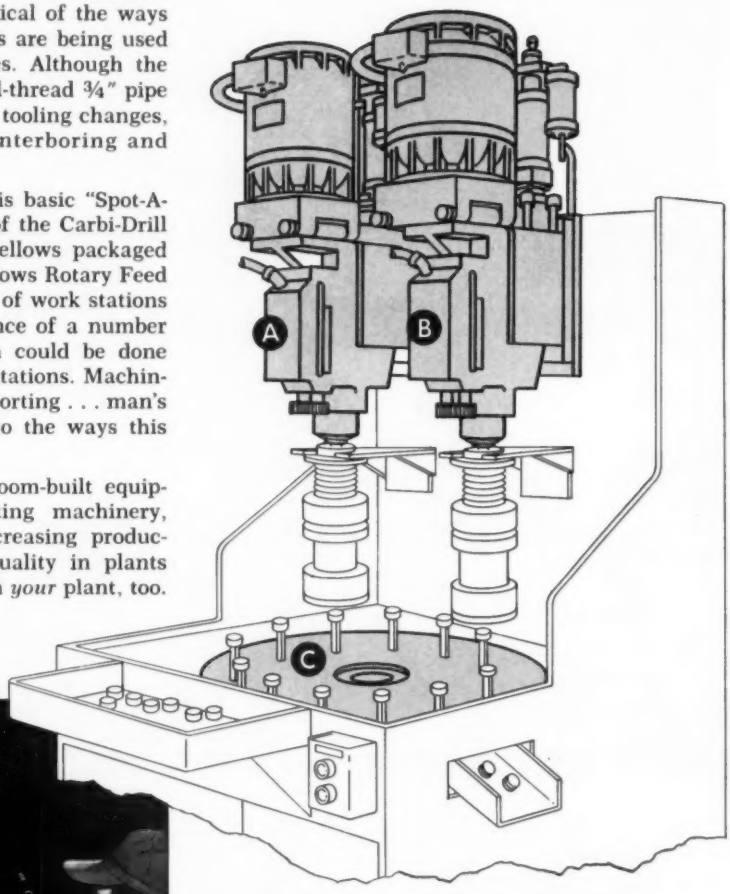
Circle 659 on Page 19

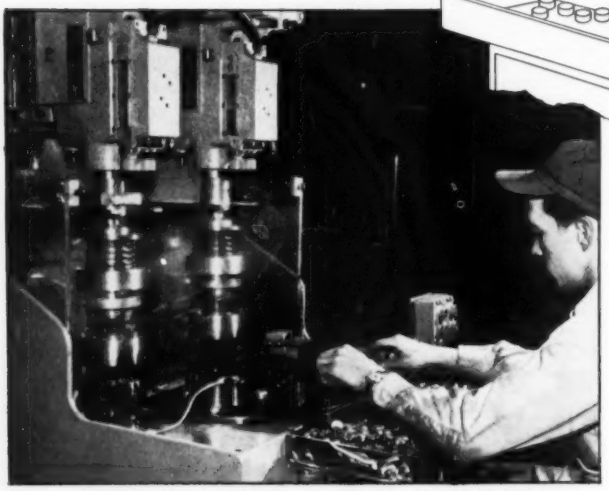
CHANCES ARE YOU CAN USE THIS "SPOT-A-MATION" IDEA TO CUT YOUR COSTS

Simple, inexpensive and easily built in the user's own shop, this "Spot-A-Mation" Idea is typical of the ways Bellows "Controlled-Air-Power" devices are being used to cut costs in all types of industries. Although the machine illustrated here is used to roll-thread ¾" pipe plugs, this same unit, with only minor tooling changes, can perform drilling, tapping, counterboring and similar operations.

Think of the many possibilities in this basic "Spot-A-Mation" Idea. For example, in place of the Carbi-Drill units, Bellows Air Motors or other Bellows packaged work units could be used with the Bellows Rotary Feed Table. On the work table, the number of work stations could be increased to permit a sequence of a number of operations, or the same operation could be done simultaneously at a number of work stations. Machining, forming, assembling, packaging, sorting . . . man's ingenuity is virtually the only limit to the ways this "Spot-A-Mation" Idea can be used.

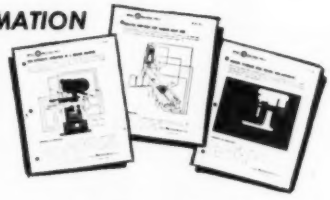
Both as the basis for low cost, toolroom-built equipment and in spot-automating existing machinery, Bellows "Controlled-Air-Power" is increasing production per man-hour and improving quality in plants throughout the world. It will pay off in *your* plant, too.





Essentially, this machine consists of two heavy duty Bellows Carbi-Drill units, "A" and "B", equipped with roll thread heads and synchronized with a Bellows Rotary Feed Table, "C", which positions work pieces. Operation is continuous and automatic. Operator merely feeds; parts are ejected automatically. Production is double that of former equipment, less skilled operators are used and rejects have been virtually eliminated.

THIS SPOT-A-MATION IDEA FILE IS YOURS ON REQUEST



Contains complete information on the above "Spot-A-Mation" Idea so that you can adapt the Bellows Rotary Feed Table with Carbi-Drill units or other Bellows packaged work units for use in your own plant, plus installation data, wiring diagrams and equipment lists for scores of other Bellows "Controlled-Air-Power" applications. Write for yours today. Address Dept. AU-260, The Bellows Co., Akron 9, Ohio.

681-C

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

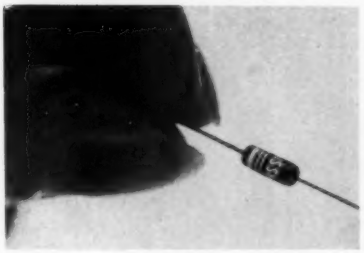
AKRON 9, OHIO

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

Circle 660 on Page 19

tive lines. The logic plates delay each signal by an amount corresponding to the distance from its sensor to the shear. The plates also accumulate the total output for each type of defect, and provide properly coded signals to operate the printer. The magnetostrictive lines are used to store the total number of feet of each type of defect, and to provide the necessary delay between the time a defect relay operates and the time that the defect reaches the shear.

Several measures have been taken to ensure reliable operation of the system. These include the provision of internal checking routines, de-rating of components, and an emergency battery power supply.



SILICON switching diodes developed by Sperry Semiconductor Div., Sperry Rand Corp., are applicable in pulse circuits for high speed computer switching, pulse clamping, gating, blocking, and logic circuits. Available in four voltage ratings, the diodes can regain 10,000 ohms resistance in a maximum time of 0.8 microsecond when a 500 ma forward pulse of 2 microseconds duration is switched to a reverse, minus 50 volts, with a loop impedance of 1000 ohms. Components operate at 150C with leakage current as small as 50 microamperes.

Equipment Leasing Shows Major Growth

CONTINUING a decade of growth, the total volume of production equipment on long-term lease to industry rose in 1959 to approximately $307 million. This compares with volumes of $227 million in 1958 and $180 million in 1957. Estimates for 1960 indicate that a total of $400 million of production equipment will be financed on long-term lease plans.

According to **Robert Sheridan**, president of Nationwide Leasing Co., a major impetus to the growth of leasing volume in 1959 was the fact that a number of equipment manufacturers started merchandising programs using leasing as a sales tool. In these plans, the manufacturers work with leasing companies to promote leasing of the equipment they produce. The leasing companies purchase the equipment from the manufacturers and lease it to customers. In 1959, about $8.5 million of the total leasing volume was placed through merchandising-lease plans.

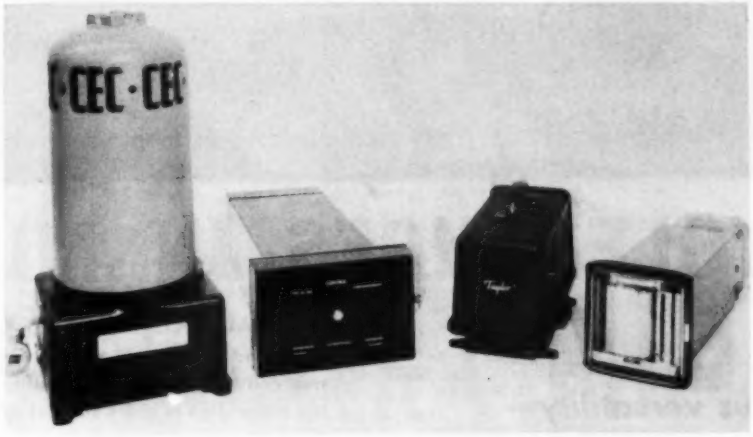
Other factors behind the development of the equipment leasing business are the growing tightness of working capital in all industries and the steadily increasing cost of equipment. These conditions make it difficult for companies to spend the capital required to acquire new equipment for expansion and modernization. With long-term leasing,

Chromatograph Adapted To Continuous Process Control

JOINT development program by Consolidated Electrodynamics Corp. and Taylor Instrument Co. has resulted in a line of equipment that permits use of a gas chromatograph for continuous, closed loop process control. The key unit which adapts the batch-type analyzing instrument for continuous control is a pneumatic transducer that stores peak values of chromatograph readings between sampling intervals.

The chromatograph analyzer determines the components in a sample by measuring the time it takes each component to be swept through a column and reach a detecting device (usually a thermal conductivity cell). Since each component has a different degree of affinity for a given column material, it will stay a longer or shorter time in the column than other components in the mixture. As each fraction emerges from the column, it produces an electrical peak signal. The position of the peak on a chromatogram (a function of the time taken to sweep the component through the column with a carrier gas) identifies the component. The amplitude of the electrical peak signal represents the concentration of the component.

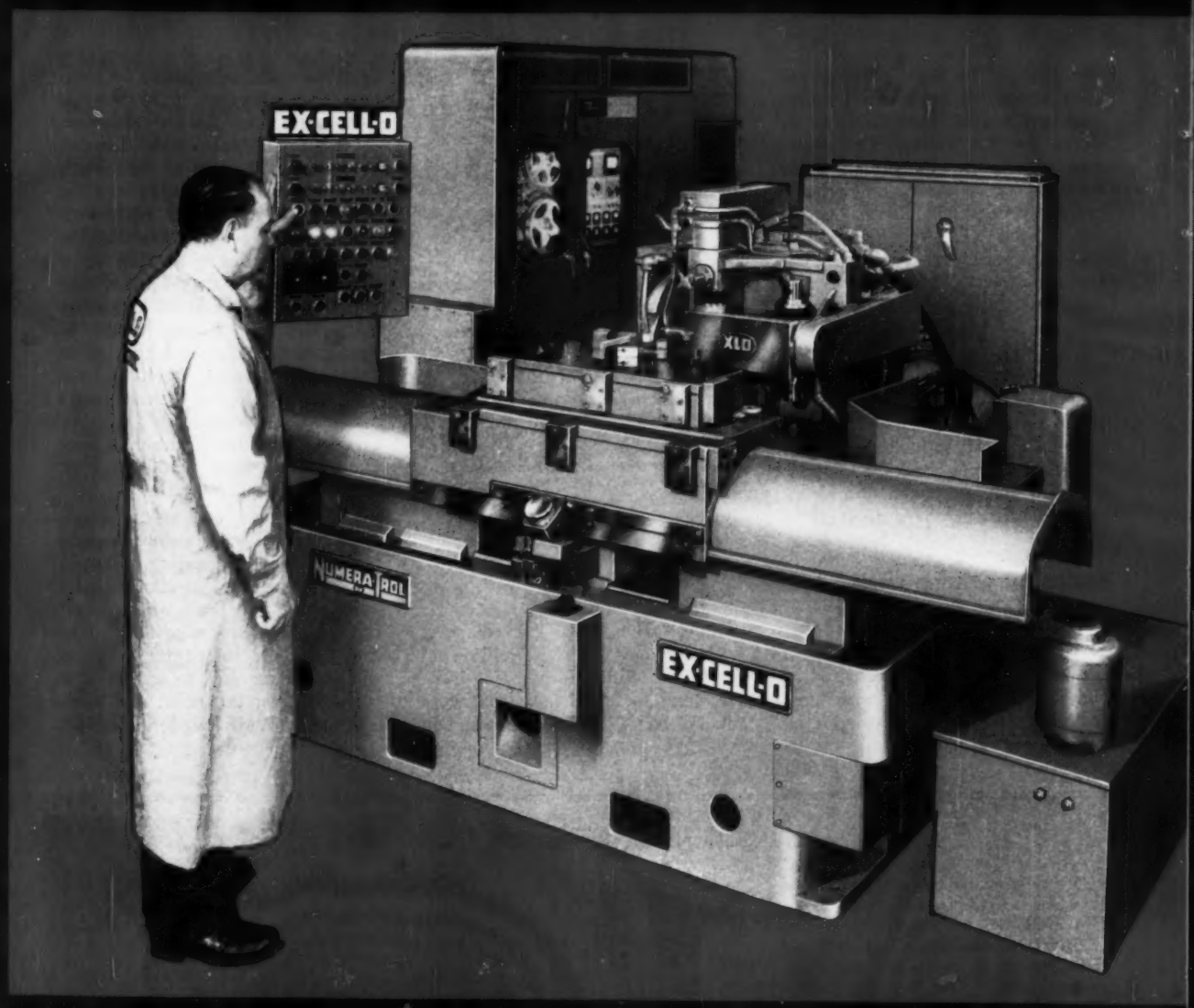
A control unit programs the entry of sample gas to the test chamber of the chromatograph. The control unit also removes heavy components from the gas to reduce the test cycle time.



Electrical output signals from the chromatograph are fed to a pneumatic transducer where they are converted to pneumatic signals. A provision in the pneumatic transducer permits storage of selected peak values for control purposes. A pneumatic recorder-controller then records these peaks and controls the process by operating a valve. The valve may be operated directly or through a controller that has its set point reset by the recorder-controller, depending upon the dynamics of the process.

Once a given signal is accepted and held by the system, control continues on the basis of that signal until a new signal arrives. The system is thus suited for automatic control where process fluctuations are relatively small.

Units from left to right in the photo are: A CEC chromatograph; a CEC programming control unit; a Taylor pneumatic transducer with memory feature; and a Taylor pneumatic recorder-controller.



TOLERANCES IN MILLIONTHS . .

Plus versatility— Interchangeable Units for tape-controlled Grinding, Turning and Boring

SPACE-AGE ACCURACY—The Standard 922 Contouring Machine's main slide and cross slide are controllable in increments of .000025" automatically or manually. Dial the dimension, from .000025" to .10", and the main slide or cross slide of this two-axis machine advances or retracts by that amount—exactly!

ECONOMY, VERSATILITY—Building-block construction permits changing in minutes from a precision grinding assembly to a precision turning-boring unit. Unitized design adds versatility, cuts downtime.

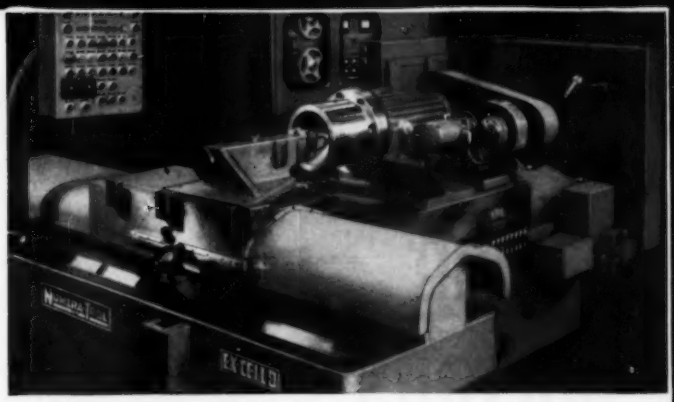
FULLY TAPE-CONTROLLED—Used with high-performance pulse data input, the Standard 922 provides fully automatic turning, boring and grinding, plus wheel dressing and dressing compensation.

TOMORROW'S MACHINES, TODAY—The Standard 922 is the latest in a line of Numera-Trol Machines performance-proved in customers' plants. Others include Precision Milling and Grinding Machines for machining turbine blades, small cams and other prototypes and production parts.

Circle 661 on Page 19

Standard Numera-Trol 922 equipped with grinding unit for precision templet grinding. Grinding assembly is easily interchangeable with boring and turning unit for accurate contouring operations.

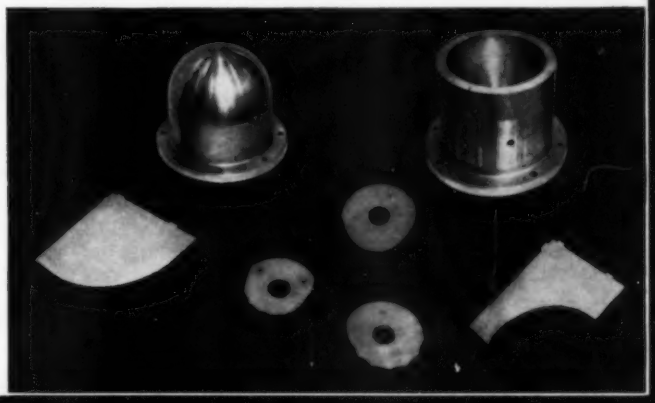
Machine is equipped for contouring by mounting boring and turning unit on main slide and tool holder on cross slide. Spindle speeds are automatically varied to maintain constant cutting speeds.



By setting dial and pressing button either slide can be moved in increments ranging from .000025" to .10" with total movement of 18" on main slide and 26" on cross slide.

Operation is monitored by electronic "Nixie" counting tubes and by direct-reading optical vernier. This mechanical and electronic read-out combination gives "closed loop" accuracy control during all operations.

Numera-Trol Contouring Machine simplifies production of parts with complex contours, ends need for blueprints and models, permits fabrication of prototypes and production parts directly from designer's mathematical directions.



with the world's most accurate production machine tool!

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"A Guidebook to Numerically Controlled Machine Tools," a valuable addition to your technical reference library, is available without cost from your local representative, or by writing direct to Ex-Cell-O.

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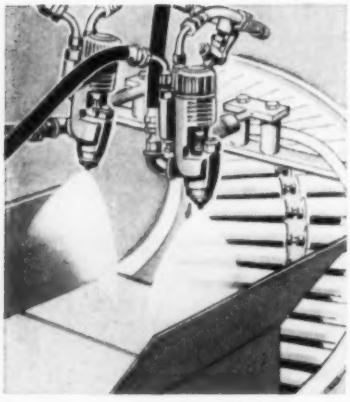
EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • TORQUE ACTUATORS • THREAD AND GROOVE GAGES • GRANITE SURFACE PLATES • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

DeVilbiss spray guns apply almost anything that pours — automatically!

Gluing cartons



For applying adhesives, DeVilbiss automatic spray guns can be set to assure just the right coverage of carton flaps without waste. Guns are split second timed and synchronized for fully automatic packaging. This or similar automatic applications are ideally suited to the versatility and flexibility of DeVilbiss automatic guns. Call our nearest representative or write direct. The DeVilbiss Company, Toledo 1, Ohio. Branch offices in principal cities.

FOR TOTAL SERVICE, CALL
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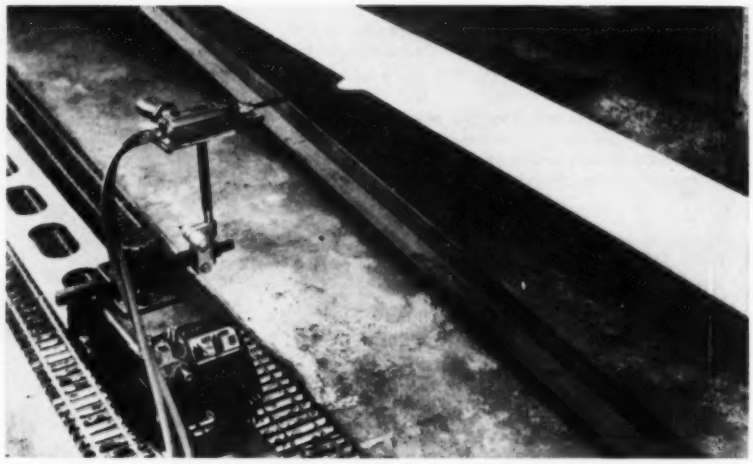
Circle 662 on Page 19



FURNACE roll used in the manufacture of silicon steel is shown receiving a bonded coating of sintered refractory material by Flame Ceramics process. Coating will reduce buildup of material on the roll that could cause dimpling of finished steel sheet. Process is also used to provide thermal protection for Diesel engine components and the combustion chambers of ramjet engines. Continental Castings Corp. has acquired patent rights to the process which was developed by Armour Research Foundation.

a company can obtain equipment as the need arises without expenditure of working capital.

The highest dollar volume of leasing in 1959 was accounted for by the following ten industries: Aircraft and parts, chemicals and drugs, electrical equipment and machinery, fabricated metal products, food products, paper and allied products, petroleum, printing and publishing, railroads, and supermarkets.

Types of equipment leased in 1959 ranged from small office machines to an automatic mail sorting system costing almost $1 million. Other leased equipment included: All types of production equipment used to fabricate wood, metal, and plastics products; computers; packaging machines; electronic equipment; and intercommunications systems.

ISA To Publish Transducer Compilation

COMPILATION and publication of specific information on the thousands of transducers used in modern instrumentation is being undertaken by the Instrument Society of America. Working through the ISA Primary Elements Committee, a special Transducer Committee will assemble, classify, collate, edit, and publish a comprehensive compendium of up-to-date information on all known transducers used in industrial, medical, biological, and military applications.

The program will embrace transducers described in published literature and those commercially available, both foreign and domestic. A bibliography of source material and a listing of manufacturers of transducers will be maintained, and periodic publication of revised editions is planned. This information will eventually be entered into information retrieval systems to facilitate rapid determination as to the availability of transducers having specific characteristics.

A transducer is defined by the ISA as any device which enables the conversion of a physical, chemical or biological phenomenon into an electrical, hydraulic, pneumatic, mechanical, optical, or other signal for transmission, recording, measurement, analysis, actuation, output, or control. Transducers have been referred to as pickups, sensing elements, primary elements, command devices, sensors, detectors and probes. Typical transducers can convert pressure, temperature, acceleration, force, mass, time, distance, and radiation into electrical form. These signals are then readily fed to amplifiers, data processing systems, or output controllers.

Sparking the project was the realization that the number and

around the triangle

EXCEEDS 200 MILLION OPERATIONS

Telephone type relay developed by Phillips Control Corp. was still cycling after passing the 200 million operation mark in a life test at 10 pulses per second. Suitable for automatic control and data processing applications, the relay employs a long coil construction that allows use of high resistance coils. Fast make and break operation can be secured with coil currents as low as 2 ma. Glass-Teflon spring and armature bushings contribute to the reliability and durability of the unit.

NEW NATIONAL OFFICERS FOR SPHE

Society of Packaging and Handling Engineers has installed new officers as of January 1, 1960. Leaders of the national organization include C. L. Lippman, president, and A. M. Lownsbury, executive vice president. Elected vice presidents were J. D. Farrington Jr., H. A. Kilmer, and K. V. Moulton.

PLANS LARGER SPIN FORGE

To satisfy aircraft and missile industry requirements for large seamless weld-free metal forms, the Hufford Div., Siegler Corp., plans to construct a scaled-up version of its regular Spin Forge machine. The new model will be capable of forming flat or semiformed metal blanks into conical, tubular, and parabolic configurations. Maximum part size will be 10 feet in diameter and 24 feet long. The forming process is one of progressively extruding a metal blank over a mandrel through controlled movement of hardened workrolls (see page 56). The development project, representing a company investment of $1.25 million, is scheduled for completion in July, 1960.

MEETING GROUND FOR COMPUTER EXPERTS

Eleven nations have ratified the statutes of the International Federation of Information Processing Societies, thus setting up a permanent, formal means whereby computer experts from all over the world may meet and exchange ideas. The Federation is an outgrowth of the first International Conference on Information Processing held in Paris last June under the sponsorship of UNESCO. According to I. L. Auerbach, who represents the National Joint Computer Committee (U. S. member of IFIPS), future activities of the IFIPS council will include planning for a second International Conference on Information Processing.

ELECTRON BEAM PROCESS WORKS HARDEST METALS

Virtually any material, including tungsten and the new exotic metals, can be machined or welded with an electron beam process developed by the Carl Zeiss Foundation of West Germany. The technique employs an electron gun that directs a controlled, high density stream of electrons onto a target in a vacuum chamber. In one production application, up to 10,000 jewel watch bearings can be loaded in the chamber and drilled in six seconds each. Holes and slots only 0.0008 inch wide may be produced in hard materials, and ⅜ inch thick stainless steel plates may be butt welded at 1/3 ips. Equipment can be manually controlled or directed by tape. Hamilton Standard, Div., United Aircraft Corp., has obtained U. S. and Canadian manufacturing, use, and sales rights for the process.

NOW YOU SEE IT, NOW YOU DON'T

Recording paper from which messages disappear immediately after recording and reappear later promises to solve the problem of maintaining privacy of communications at the receiving end of facsimile systems. The paper can be processed into envelopes while blank, so that only the original sender and the recipient see the message. Military, Post Office, and business applications are foreseen for the new material. Developed by Alfax Paper & Engineering Co., the paper was demonstrated recently by Alden Electronic & Impulse Recording Equipment Co.

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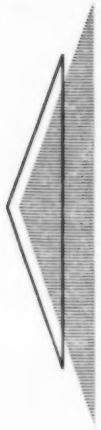

For your convenience, advertisements and items of information on new equipment, components and manufacturers' literature can be quickly identified by an *Item Number* accompanying each unit.

For additional free information circle item number on an inquiry card. Fill in your name, title, address, etc.—Drop it in the mail—Your request will receive prompt attention and will be filled directly by the manufacturer.

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428	468	508	548	588	628	668	708	748	788	828
429	469	509	549	589	629	669	709	749	789	829
430	470	510	550	590	630	670	710	750	790	830
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432	472	512	552	592	632	672	712	752	792	832
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Charter Granted To Manufacturing Engineering Council

NEWLY CONSTITUTED national organization, named Manufacturing Engineering Council, has been established to serve the particular interests and needs of engineers and management people engaged in manufacturing engineering. A primary function of the group will be to set up channels for the interchange of ideas and experiences aimed at solving the increasingly complex problems brought on by demands for more automatic manufacturing techniques.

First official meeting of MEC will be held during the Fourth Conference on Manufacturing Automation at Purdue University on April 11, 12, and 13 (for further details of this event see page 10). Policies and objectives of the organization will be discussed, and elections will be held at this meeting.

Inquiries concerning membership in the Manufacturing Engineering Council should be directed to Frederick I. Ellin, acting chairman, Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill., or Michael Zajac, acting vice chairman, Buhr Machine Tool Co., 839 Green St., Ann Arbor, Mich.

applications of transducers are increasing at a rate beyond the capacity of any individual to be familiar with them, even in specialized fields. Information on transducer capabilities and performances now appears in a wide variety of scientific and technical journals, trade publications, and commercial advertisements. The lack of ready availability of this information, however, has tended to slow the pace of technical progress in a number of fields. Frequently, time has been wasted in the design of new transducers when satisfactory units had already been developed in other fields.

Compilation and publication of the first volume is expected in January, 1961. The basic source materials will be kept current by periodic checking with both the original and new sources of data. Periodic publication of revised editions is also planned.

Operations Research Study Cuts Mail Sorting Time

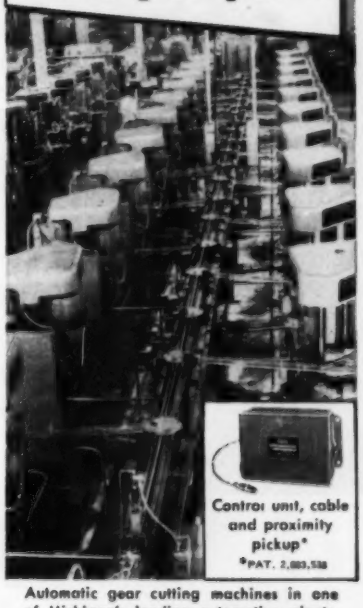
SORTING time reductions up to 58 per cent have been effected at the main sorting post office in Detroit as a result of a study conducted by Automation Management Inc. and Broadview Research Corp. More than half the delay reductions were by 25 per cent or more, and one quarter were by 40 per cent or more, for 20 representative destinations chosen to evaluate the program. No new machines were required, and but one clerk was added to a labor force that may include as many as 600 workers in peak hours.

In the first part of the program, Automation Management Inc. conducted a six-week investigation of all outgoing letters passing through the office. This investigation revealed that the major portion of the 4 to 5 hours that a letter might spend in the sorting office was in waiting. Broadview Research Corp. was then engaged as a subcontractor to conduct an operations research study aimed at minimizing the waiting time within existing manpower and facility limitations. The study, based on a special form of the theory of queues, enabled matching of manpower to variable mail inputs so as to minimize waiting times.

To more fully exploit the operations research findings, Automation Management Inc. has devised techniques for improved data reporting and interpretation. These techniques will make available to the shift superintendent current and cumulative data on labor used, mail processed, and waiting time at each station. Decision rules developed by the operations research analysis will then be applied to determine

EPL proximity transducer system* ups gear production

1,552,400 units per year!



Automatic gear cutting machines in one of Michigan's leading automotive plants.

400% increase over manual feed!

Automatic gear production line in this plant is monitored by 300 proximity transducers that make stock blank feeding completely automatic. When this system was started in 1957, production figures jumped from 400,000 gears (1956) to 1,922,400 per year.

It's obvious that production increases like this give tremendous savings in time and labor costs. EPL systems can do the same for your operation—investigate today!

Other Industrial Uses

• Automatic Production Lines • Conveyors • Parts Feeders • Printing Equipment • Machine Tools • Packaging Machines

Write for free descriptive literature now!

Electro	Electro Products Laboratories
Sensing Elements for Control, Counting, Speed and Displacement Measurements	4501-A Ravenswood Chicago 40, Ill. Canada: Atlas Radio Ltd., Toronto 9679

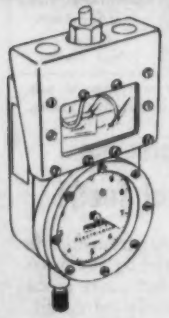
Circle 663 on Page 19

Lights show size category. Actual work size is shown on the dial.

faster gaging . . .

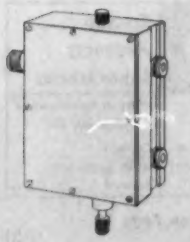
ELECTRIFYING RESULTS . . .

when you use the ELECTRICATOR



WETPROOF STYLE
(For each regular model)

DOUBLE UNIT MODELS
(Four limits, five categories)



ECCENTRICATOR
(For indicating eccentricity, runout, squareness)

There's nothing quite like the Federal Electricator — so easy to apply — so economical — so accurate . . . a Miracle Movement Dial Indicator and two-limit, spindle-actuated switch combined. Use it with tolerance lights in place of your dial indicator for faster, more accurate bench gaging. Use it together with a signal unit for fully automatic inspection or automatic machine or process control.

The Electricator is a high precision unit — switching accuracy is better than 50 millionths on all models. Voltage across the switch is extremely low and switching current is in the order of one milliampere. Therefore, arcing and pitting of contacts is eliminated and accuracy is reliably maintained. The Electricator is calibrated, so it requires only one master.

All Electricator models incorporate the new Federal Miracle Movement which is so wear-resistant . . . so shock resistant . . . you will probably never have to repair or replace it. Six regular models are immediately available from stock. Four different graduations — .0001", .00025", .0005", .001". Prices from $75.

The switching portion of the Electricator is available as a separate unit to operate tolerance lights and/or provide control limits without indicating actual size.

The Federal Eccentricator, a similar type of high precision unit, indicates eccentricity, runout, squareness, etc., *without* being influenced by normal piece-to-piece variations in size.

For more information, write . . .

FEDERAL PRODUCTS CORP.
6392 Eddy Street, Providence 1, R. I.

Ask **FEDERAL** *First*

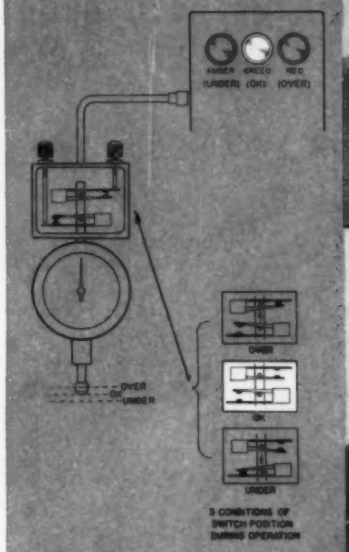
FOR RECOMMENDATIONS IN MODERN GAGES . . .
Dial Indicating, Air, Electric, or Electronic—for Inspecting, Measuring, Sorting, or Automation Gaging

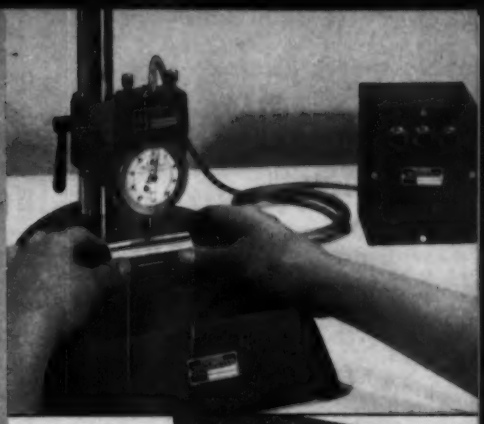
Circle 664 on Page 19

FOR HIGH SPEED BENCH GAGING
(Single or Multiple Dimensions)

It's easy to install the Electricator in place of the dial indicator on your present comparator when you need greater speed. The Electricator eliminates having to make borderline decisions so you get more reliable results . . . and faster results . . . using less skilled help, and with less operator fatigue. Many concerns have up-graded their manual gaging this economical way with great success.

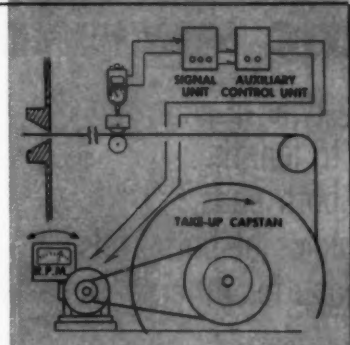
The Electricator offers the most economical way to make multi-dimension checks rapidly and reliably. The signal lights on its control panel instantly show the operator whether the piece is within tolerance or not. No need for operator to look at a group of indicators one by one in order to determine acceptability.

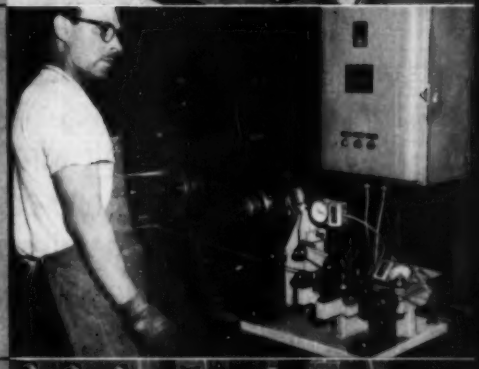




CONTINUOUS PROCESS CONTROL

Because the Electricator is compact, it can be installed easily on most continuous processes to indicate size trend accurately so correction can be made *before* scrap is produced. In many cases, Electricator, working into appropriate signal unit, can be used to *control* size so process automatically produces within tolerance.

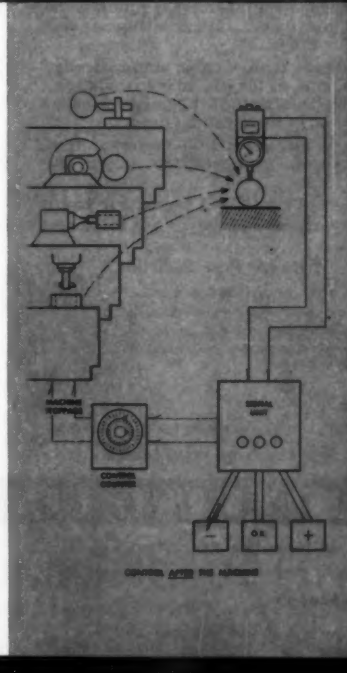


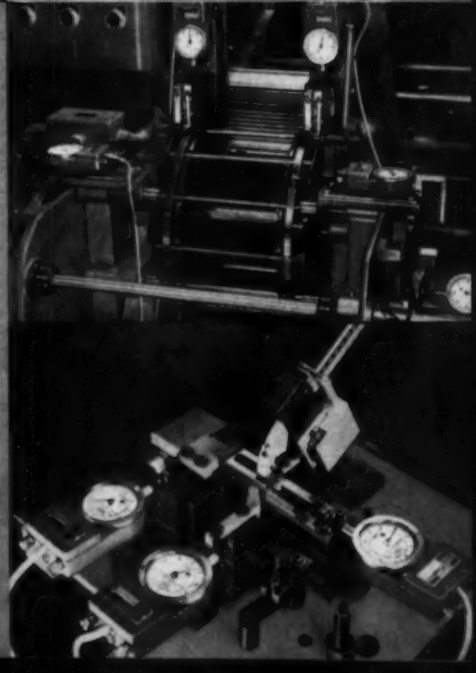


HIGH SPEED AUTOMATIC MULTI-DIMENSION INSPECTION AND MACHINE CONTROL

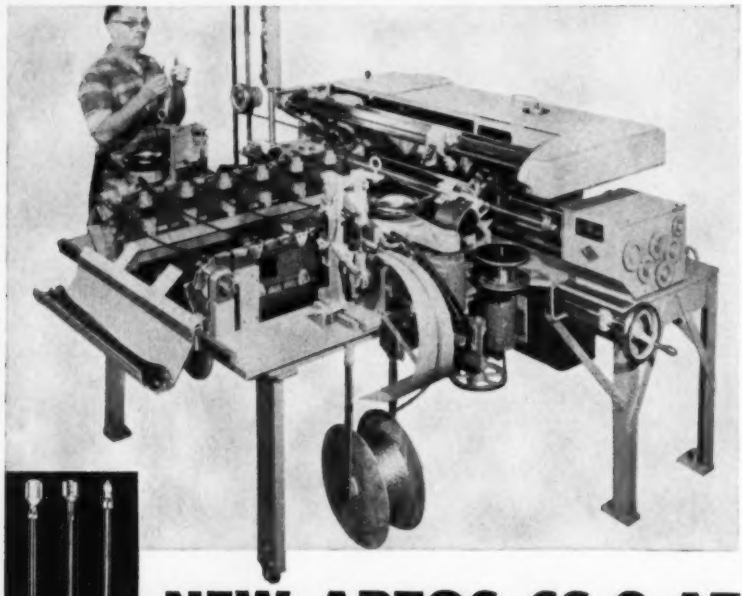
Electricators have rapid response — can gage and sort up to 6,000 pieces per hour, providing up to 5 sorting categories. Wide range adjustment of limits to suit tolerances. Use of low switching voltage and current provides high-reliability performance.

Electricator can also provide post-process machine control in addition to high-speed gaging and sorting. Using simple control counter, gage automatically stops machine when tolerance limits are exceeded.





Produce 4,000 finished wire leads per hour...with terminals at both ends!



NEW ARTOS CS-9-AT AUTOMATIC MACHINE

1. measures any type of wire.
2. cuts off wire to length.
3. strips one or both ends.
4. attaches terminals at both ends.
5. provides stations for other work.

NOW YOU CAN produce up to 4,000 finished wire leads per hour—*with terminals attached at both ends*—when you install this new high-speed machine.

The ARTOS CS-9-AT handles almost any type of cable automatically. Taking wire from the reel, it measures, cuts to length, strips insulation, attaches terminals and provides uniform collection of the finished leads. Most types of terminals in prefabricated strip form can be used.

Also, the machine is furnished with a multi-station conveyor that permits several stations to be used for secondary operations such as inspection, twisting, welding, etc.

Get the complete story on the new ARTOS CS-9-AT—ask for engineering advice on your special problems.

ARTOS CS-9-AT CAPACITY

Wire Sizes: 20-gauge to 4-gauge.
Cutting Lengths: 6" min. to 90" max.
Stripping Lengths: 3/16" to 1 1/2".
Output: 5"-45" lengths—4,000 per hr.
45"-90" lengths—2,000 per hr.

AGENTS THROUGHOUT THE WORLD

Write for Free Bulletins

Bulletin 358 describes CS-9-AT machine. Also ask about other Artos machines to handle wire from 30 to 000 gauge; cut lengths from 2 in. to 15 ft.; strip insulation from 3/16 in. to 10 1/2 in.

World Leaders in Automatic Machines for Finishing Wire Leads

ARTOS ENGINEERING CO.

2785 South 28th Street • Milwaukee 46, Wisconsin

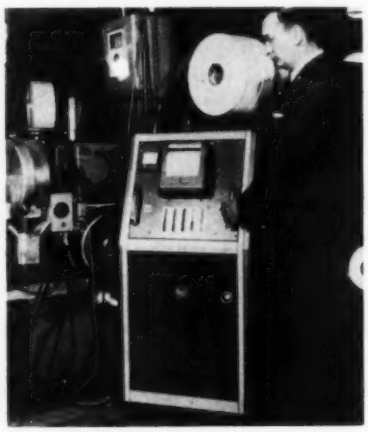
the best manpower changes.

Procedures developed in this application may be usable in other industries where it is desired to minimize delay times of items undergoing processing. These include industries where material being handled is perishable, has high inventory costs, or priority value.

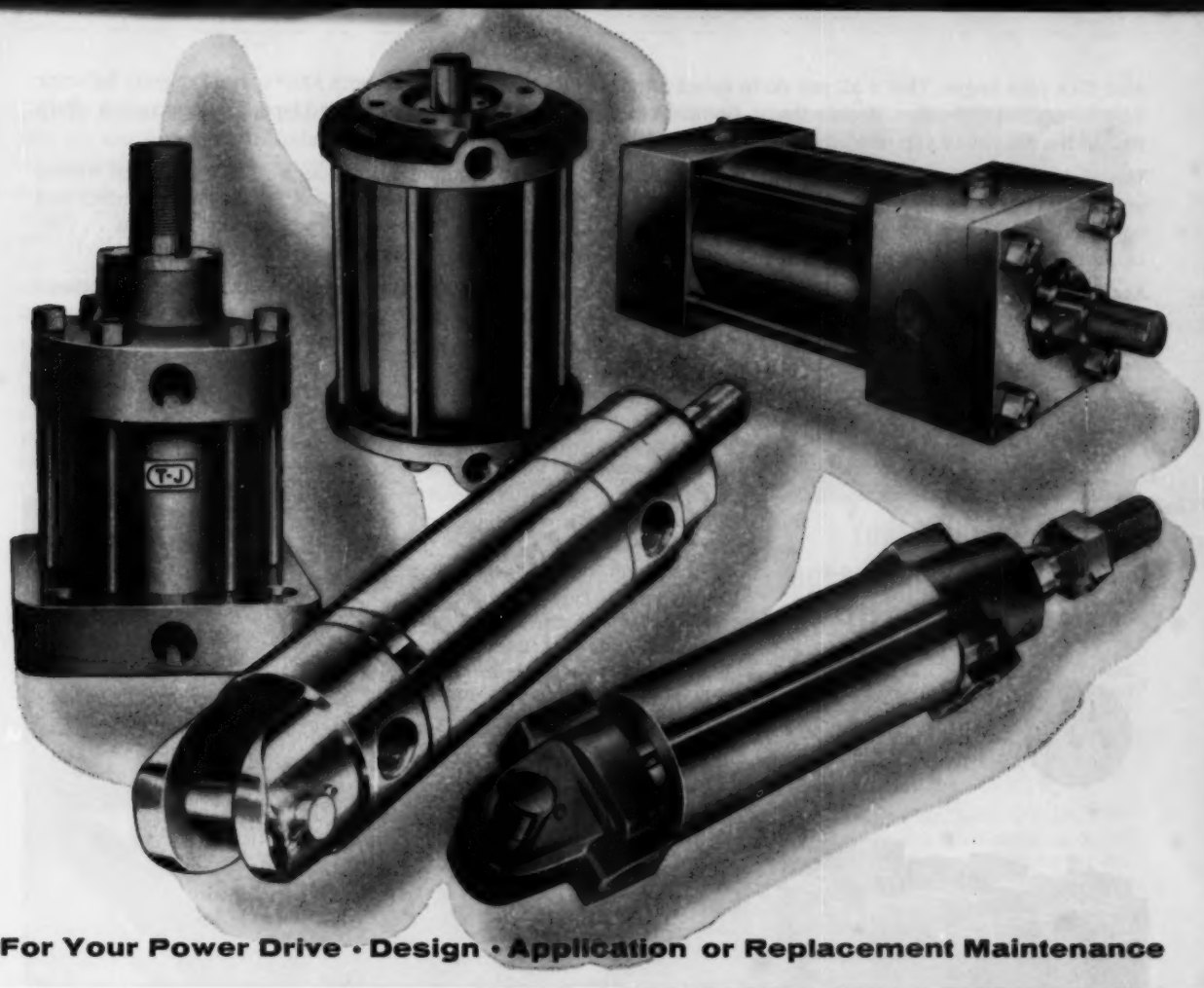
Techniques For Measuring High Pressures Under Study

INCREASING numbers of industrial products require the use of high pressures at some stage of their manufacture. For example, high pressures can cause chemical changes that form useful compounds such as polyethylene and boron nitride. In other cases crystalline changes are the objective, as when graphite is changed to diamond, or quartz to Coesite, under high pressures.

To meet growing industry and military requirements, the National Bureau of Standards has expanded its pressure standards program to include development of improved standards and techniques for measuring very high pressures. At the



PORTABLE instrument developed by American Machine & Foundry Co. electronically counts and inspects product units and computes individual standard deviation values for quality control purposes. Results may be presented on a meter scale, recorded on a chart, or printed in digital form on paper tape. In the application shown, 2000 finished cigarettes are checked for conformance to quality and weight standards in less than two minutes. Unit is adaptable to quality checking of other products such as screw machine parts, stampings, and items in canning and processing industries.



For Your Power Drive • Design • Application or Replacement Maintenance

There's a T-J CYLINDER

That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application – with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

Plus

THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.

SQ-1058-4 for the T-J Squair Head cylinder.

No. 54 for standard tie-rod air cylinders.

SM-56-3 for the incomparable Spacemaker cylinder.

HSM5-56-4 for the High-Pressure Hydraulic Spacemaker cylinder.

THE TOMKINS • JOHNSON CO. JACKSON, MICH.

CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS

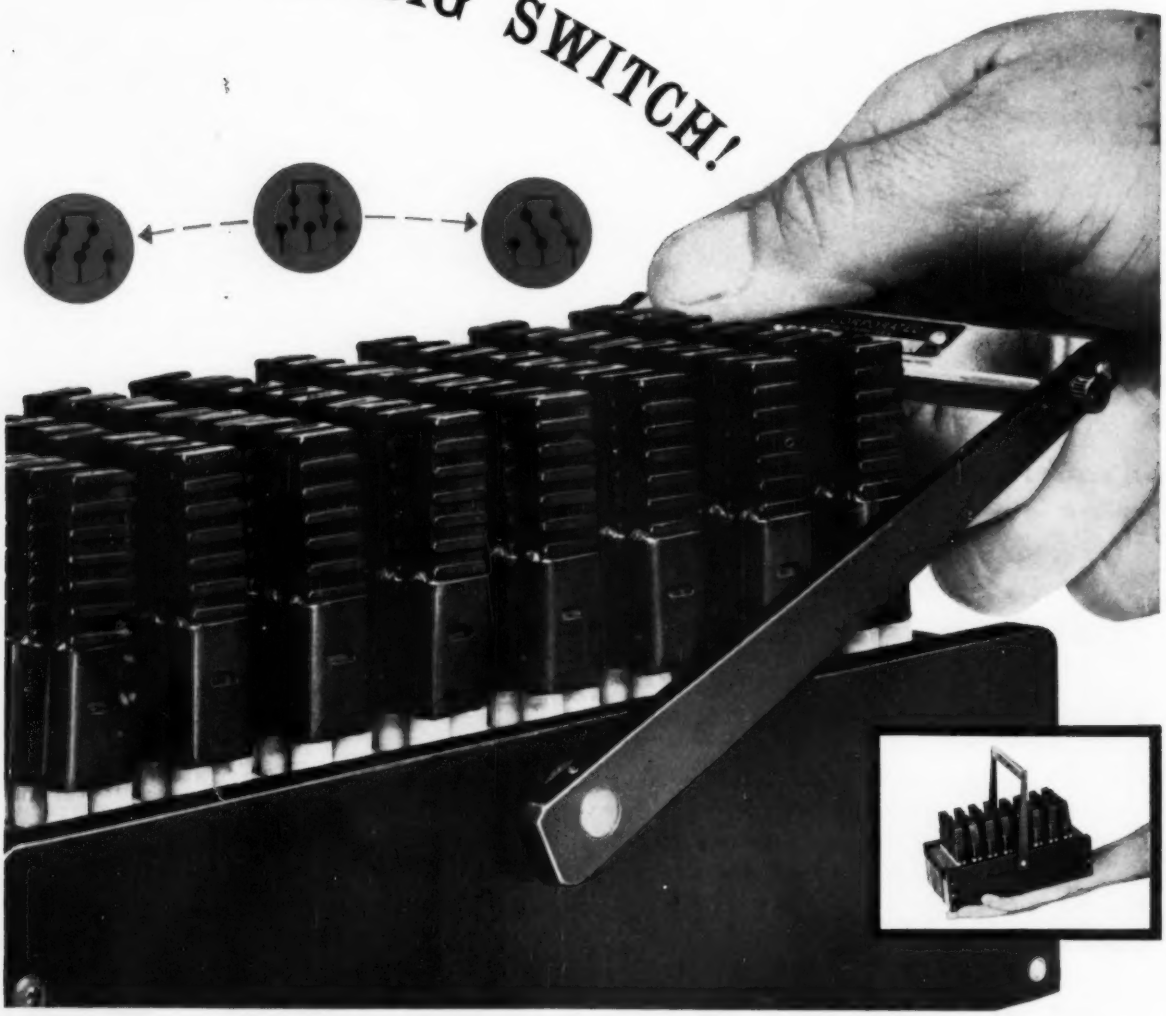
Circle 666 on Page 19

Just flick your finger. That's all you do to select either of two circuit programs with AMP's new Program Selector Switch—up to 1500 poles, double throw. Compact in size, available in a fully shielded type, this new switch offers you all the reliability you need for any critical dry-circuit application.

The flick of your finger also pre-cleans all contacts for assured conductivity through AMP's patented wiping action. You get uniform pressure on all contacts . . . choice of tin or gold contact finish . . . exclusive contact and spring design plus many other features from AMP's industry-proved Patchcord Programming Systems . . . including A-MP Taper Pins, crimped to your leads and inserted into taper receptacles in the rear of the switch.

And—for flexibility, you can make a combination plug board and double throw switch with all throw positions independently patched.

THE BIG SWITCH!



Make the big switch to the A-MP Double Throw Program Selector Switch. Send today for more information.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

present time, pressures above 200,000 psi are measured by reference to approximately known pressures at which there are changes in phase, volume, or electrical resistance of certain materials. Bismuth, for example, undergoes abrupt resistance changes at 365,000, 385,000 and 1,700,000 psi. Barium experiences this phenomenon at 1,100,000 psi. Because these and other common reference values were obtained with different types of apparatus at widely different times, there may be inconsistencies between them. An objective of the standards program will be to fix these values accurately.

In another approach, the Bureau will attempt to refine equipment now used to generate and measure pressures below 200,000 psi so that it can be applied at higher pressures. It is expected, for example, that dead weight loaded type instruments may be found usable, with fluid pressure media, at pressures as high as 400,000 psi.

School Trains Personnel In Numerical Control

NUMERICAL control of machine tools is a relatively new manufacturing technique. Therefore, present scheduling, operating, and maintenance personnel may experience difficulty in learning to efficiently utilize their equipment. This situation, in the face of forecasts that approximately 50 per cent of the dollar volume of machine tools sold in the mid 60's will be numerically controlled, suggests that a severe shortage of skilled personnel may soon develop.

To assist industry in the transition from conventional to numerically controlled machine tool operation, the Industrial Controls Section of Bendix Aviation Corp. has set up a numerical control training program for part programmers, operators, and maintenance men. User-company personnel are also trained at the school.

The training program includes instruction in all phases of part programming and processing, including computer and manufacturing procedures. In a one-week period, engineers are instructed in the requirements of numerical drawings and the translation of basic manufacturing information into a numerical form that is acceptable for input to a computer. Included is instruction in various computer routines that greatly simplify and reduce the work required in part programming.

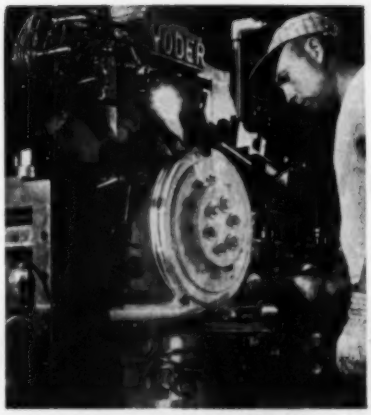
Maintenance of the electronic and hydraulic equipment included with the numerical control system is also taught. For continuous path systems, the course in electronic maintenance runs for three weeks and covers logic, electronics, and maintenance procedures.

Experience to date indicates that the training program is an effective aid in reducing numerically controlled machine tool downtime. As an example, reports from trained users who have taken full charge of maintenance of the numerically controlled equipment in their plants indicate that unscheduled downtime due to electronic failures is averaging less than 5 per cent.

KEY INDUSTRY in America's defense is one of the country's smallest. There are only about 1600 scientific apparatus makers in the United States, many employing fewer than 25 persons.

SPOTLIGHTING PEOPLE

H. H. Adams, vice president, appointed manager of the Power Cylinder Div.; **Z. J. Lansky** named manager of the Valve and Crown Div.; and **M. E. Lawrence** named manager of the Machinery Div., Hannifin Co., Div., Parker-Hannifin Corp. . . . **Francis J. Dunleavy** appointed general manager of Industrial and Automation Div., Radio Corp. of America, with responsibility for newspaper automation equipment, materials handling devices, metal grinder controls, and electronic inspection units for beverages, foodstuffs, metal products, and plastics. . . . **Dr. John G. Hutton** named general manager of Specialty Control Dept., General Electric Co. . . . **Charles Benton Jr.** elected president, Federal Systems Div.; **Gilbert E. Jones** elected president, Data Processing Div.; **William B. McWhirter** elected president, Data Systems Div.; and **Orland M. Scott** elected president, General Products Div. of International Business Machines



Yoder Tube Mills speed tailpipe production at AP Parts Corporation

The AP Parts Corporation (Toledo, Ohio), world's largest producer of replacement mufflers and tailpipes, uses 2 YODER Tube Mills to produce more than *300* ft. of 1¾", 1⅞" and 2" tubing per minute.

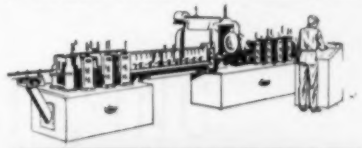
According to Mr. John Grindle, Plant Engineer, the two-man operated YODER Mills are vital to the production of the entire plant. "YODER Tube Mills earn their keep daily. They are easy to set up, maintain and operate . . . the welds are clean and uniform. We depend on them for constant quality, high production and minimum downtime".

The YODER Tube Mills at AP Parts exemplify the production economies and dependability of all YODER-built equipment, whether it be Pipe and Tube Mills, Cold Roll-Forming Machinery or Slitting Equipment.

If your products require ferrous or non-ferrous pipe or tubing, from ¼" to 26" diameters, there is a YODER Mill designed to produce it economically, accurately and efficiently.

For complete information on YODER Pipe or Tube Mills . . . write for the fully illustrated, 88 page YODER Tube Mill Book . . . it is yours for the asking.

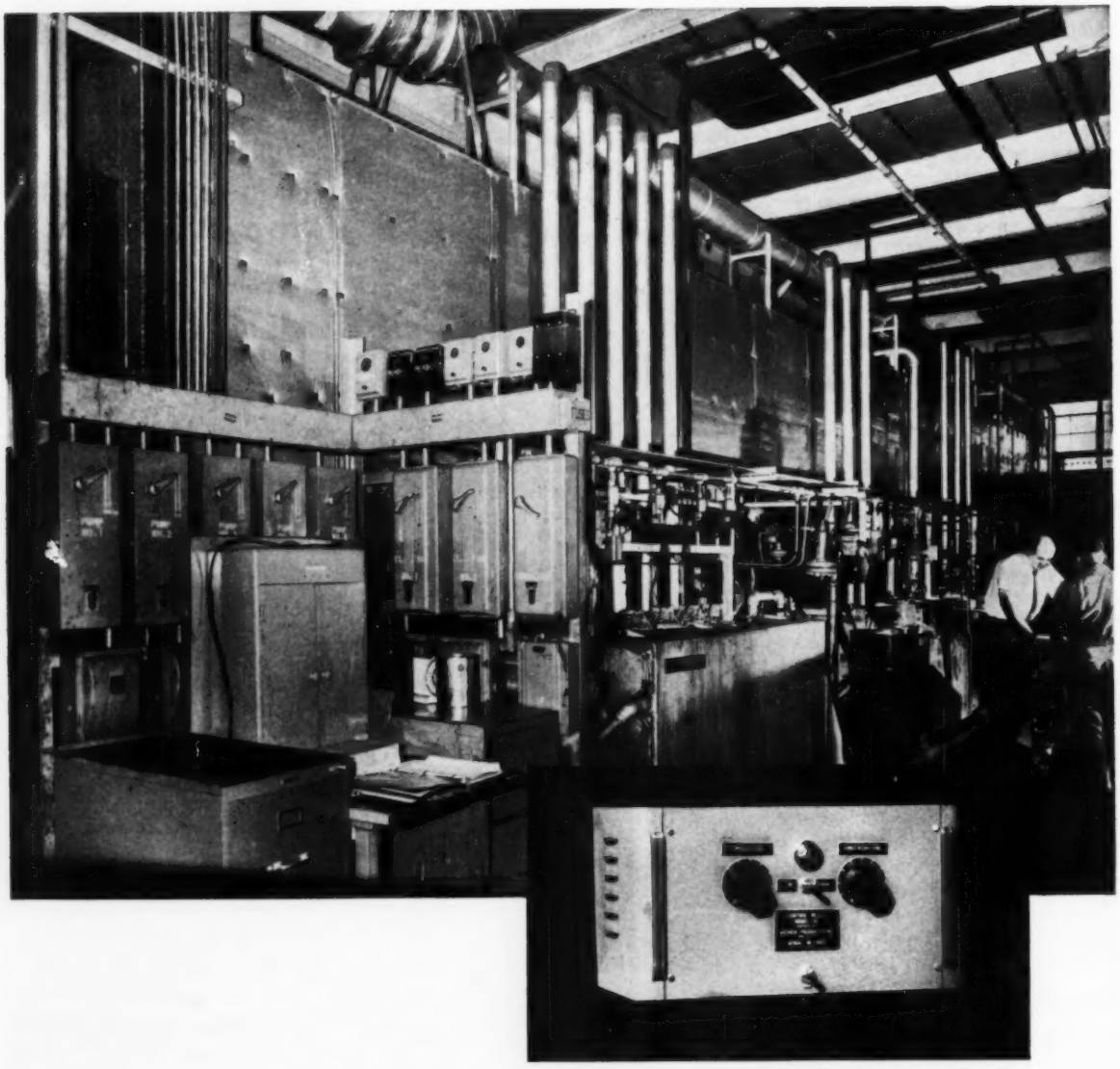
THE YODER COMPANY
5526 Walworth Avenue • Cleveland 1, Ohio



ENGINEERING YODER MANUFACTURING
PIPE AND TUBE MILLS
(ferrous or non-ferrous)

Circle 667 on Page 19

AMCHEM AUTOMATION...a new



Many industry leaders in iron, steel and aluminum fabrication are already employing AMCHEM AUTOMATION to provide unmatched product protection and gratifying production savings to these products—aluminum siding, appliances, venetian blinds, fluorescent lighting fixtures, aluminum sign blanks, steel office furniture, automotive trim, aluminum windows and doors. Give your product the same protection, the same kind of savings — with AMCHEM AUTOMATION!

concept in chemical conversion coatings assures you constant, uniform quality, actually saves you money!

AMCHEM AUTOMATION means new standards of protection for your metal products with actual black-and-white savings in time and money you can't afford to ignore!

AMCHEM AUTOMATION takes the human element out of your conversion coating processing—replaces it with 100 percent electronic line control that virtually assures you of constant, uniform quality. Rejects due to faulty bath control plunge to new lows. Product assembly moves faster through inspection as AMCHEM AUTOMATION guards quality round-the-clock!

AMCHEM AUTOMATION releases quality control personnel to other duties, builds employee morale and pride in their work. AMCHEM AUTOMATION watch dogs chemical replenishment—bath is never overloaded or under strength. You reap big savings in time, labor and chemical costs!

AMCHEM AUTOMATION can be yours right now for metal pre-treatment and protection on a variety of fabricated products. Just say the word, we'll have an Amchem Automation Coordinator—a specialist in electronic line control—fill you in on all the time, money and labor saving details!

AMCHEM

AMCHEM PRODUCTS, INC.

(Formerly American Chemical Paint Co.)

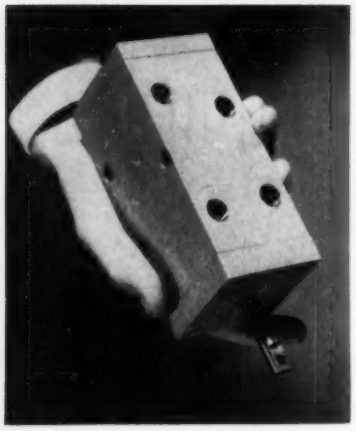
First in automated chemical conversion processing

AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

Amchem is a registered trademark of **AMCHEM PRODUCTS, INC.**

Circle 669 on Page 19

Typical Control Functions solved by AIR CIRCUITRY



Westinghouse Multi-Position Cylinder

The Westinghouse Air Brake Company's complete line of AIR CIRCUITRY components contains a wide variety of pneumatic positioners to handle almost all of your force and positioning requirements.

No longer is pneumatic positioning limited to a single or double acting cylinder. Remotely controlled by directional and/or pressure control valves, both variable and fixed force and positioning is possible. Along with all the advantages of air, these devices are easily maintained and serviced. Uncomplicated and rugged, pneumatic positioners may be the answer to your control problems.

Typical Applications—The illustrated positioners have been used in almost every field of industry today. These positioners can:

clamp	punch	snub	convey	push
rotate	lock	form	bend	blank
index	broach	crimp	cushion	pull
hold	squeeze	twist	stretch	eject
feed	shear	raise	brake	move
pierce	lower	press	turn	coin

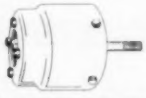
If you have a positioning problem, let us know about it. It can probably be solved with AIR CIRCUITRY. For more information, ask for our catalog on Positioners.

What is AIR CIRCUITRY?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise AIR CIRCUITRY is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

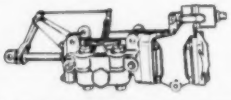
1. ONE AND TWO STATION POSITIONING—Single and double acting cylinders can perform all types of force and positioning functions. The Westinghouse line of cylinders includes diameters from 1" to 10"; strokes to suit application; single and double end; foot, swivel, flange and trunnion mounts.

2. MULTI-STATION POSITIONING—Controlled by an associated directional valve, these cylinders attain 3, 4, 5 and 7 fixed positions of stroke. Three position cylinders are available in 2", 3", 4", 5" and 6" diameters. Strokes may be obtained to suit application.



3. VARIABLE FORCE AND POSITIONING—Diaphragm type cylinders are controlled by manually or mechanically operated pressure control valves to achieve a variable force or position of the rod. Various diaphragm areas and strokes available.

4. INFINITE POSITIONING-LIGHT—The actuator positioner has an infinite number of positions, governed by the amount of air pressure acting on its spring opposed diaphragm. Remotely operated pressure control valves dictate the position of the operated lever. This device has a low force rating.

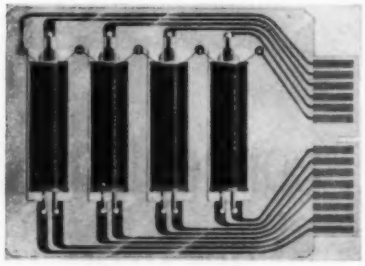


5. INFINITE POSITIONING-HEAVY—The Westinghouse PNEUDYNE® Positioner can position accurately, independent of the opposing force, up to its power capacity. The power capacity is determined by piston size and supply pressure. Remotely controlled by pressure control valves, this device maintains its position throughout changes in the opposing force.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA



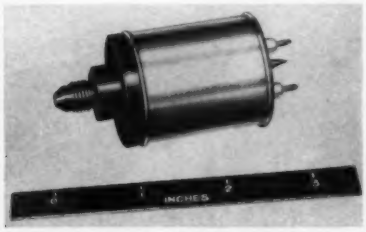
PRINTED circuit board mounting of relays permits plugging these components into consoles along with the logic circuits they serve. In a design developed by C. P. Clare & Co., mercury-wetted contact relays are assembled to printed circuit boards and sealed from dust, moisture, and tampering by the application of a vinyl film material. Other relay models and components are adaptable to the new process.

Corp. . . . **Kenneth M. Lord** appointed vice president and general manager; **Leslie D. Catlin** named director of management services; and **David Y. Keim** appointed director of engineering of Electronics Div., Stromberg-Carlson, Div., General Dynamics Corp. . . . **Chris H. Bartlett,** vice president, named deputy general manager, East Pittsburgh Div., Westinghouse Electric Corp. . . . **Thorwald S. Ross Jr.** elected vice president in charge of manufacturing and **Walter C. Woodworth** appointed manager of production and procurement, Rivett Lathe & Grinder Inc. . . . **Dr. Robert C. Langford,** chief engineer for research and development, Weston Instruments Div., Daystrom Inc., elected chairman of the Instrumentation Div., American Institute of Electrical Engineers. . . . **George Rienerth** appointed products manager of Electric Controls Div., National Acme Co. . . . **Bert Woldring** named vice president in charge of sales and product development for Control Design & Fabricate Inc. . . . **John R. Warnock,** general manager of marketing; **Richard L. Campbell,** director of engineering; and **George F. Butterfield,** general manager of manufacturing, have been elected vice presidents of Detroit Controls, Div., American Radiator & Standard Sanitary Corp. . . . **Eugene R. Meinecke** appointed chief design engineer for Chainveyor Corp. . . . **John H. Greening** named director of engineering for Micromatic Hone Corp. . . . **Edwin A. Munschauer Jr.** appointed direc-

tor of research at Niagara Machine & Tool Works. . . . **Edward Rathje Jr.** named manager of the Development Section of Teleregister Corp.

SPOTLIGHTING PLANTS

Eaton Mfg. Co. has announced that its wholly owned subsidiary, Cleveland Worm & Gear Co., and the latter's subsidiary, Farval Corp., will become divisions of Eaton. The new divisions will operate under their present names. . . . **A. O. Smith Corp.** has announced an expansion program that will result in a 45 per cent increase in production area for manufacture of integral, fractional, and hermetically sealed electric motors in its Electric Motor Div. . . . **Minneapolis - Honeywell Regulator Co.** has changed the name of its facility at Beltsville, Md. to Industrial Systems Div. The plant, formerly the Davies Laboratories Div., produces analog and digital magnetic tape systems and components. . . . **Milro Controls Co.** has completed a move to new quarters in Saddle Brook, N. J. This will permit expanded production of magnetic components and systems and various types of instrumentation systems. . . . **Narda Ultrasonic Corp.** has acquired additional floor space that will be used for research and development of ultrasonic cleaning systems and process devices. . . . **Waterman Hydraulics Corp.** is the new name for Waterman Engineering Co. . . . **Radcor Inc.** has been recently formed to supply infrared



ABSOLUTE pressure switches developed by Consolidated Controls Corp. are suitable for continuous duty at temperatures from minus 65 to plus 1000 F. Designed especially for high temperature applications, units are available in pressure ratings from 20 to 200 psi with accuracy of 10 per cent. Differential between make and break of SPST contacts on increasing and decreasing pressures is 2 psi maximum. Switches sense pressures in media such as air, oxygen, steam, and hydraulic fluids.

Specially designed with the APPLICATION in mind!

TYPICAL EQUIPMENT POWERED BEST BY BALDOR MOTORS

Blowers
★
Fans
★
Ventilators
★
Agriculture dryers, cleaners, separators
★
Conveyors
★
Woodworking machinery
★
Abrasive saws (masonry & steel)
★
Pumps
★
Compressors
★
Machine tools

BALTRIC line of BALDOR motors

No guesswork here! Now you can stop fitting the machine to the motor.

Famous Baldor Streamcooled Motors featuring TEFC construction, are engineered and designed to fit *specific* applications—your guarantee of getting the *one right* motor that will deliver the power and performance to make your equipment operate at top efficiency.

There's a highly trained and experienced Baldor representative near you who will be happy to show you how this "tailored-to-the-job" type of engineering can help cut costs and improve the performance of your equipment. Contact him direct or write to . . .

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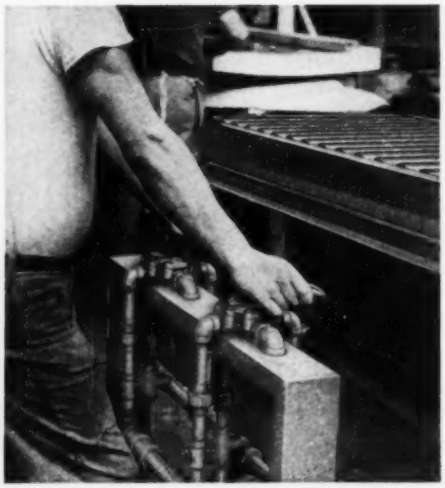
Circle 671 on Page 19

Shipping end of new Logan conveyor at Weirton Steel Co., division of National Steel Corp., Weirton, W. Va.

Logan *Plant-Dynamation* speeds

Line weighing station of the Weirton system is a Logan-installed hydraulic lift which operates recording scales. Custom cut bundles weigh in at 1,500 lbs. to 10,000 lbs. Gravity rollers at the series of work stations are succeeded by live roller sections which hurry the bundles on to shipping. In the shipping area, gravity sections take over once more.



Hand-controlled hydraulic brakes and electric start-stop buttons give conveyor sections full flexibility of pace. Constantly varying size of bundles and differences of work time for different steps dictated this important design feature.

Now each man bundles steel 15 times faster. A crew of seven men now wraps and bands over four times as much custom-sheared strip steel as 26 men could before the system was installed. Steel moves from shearing area on a series of live roller sections separately controlled by crane operators (left, above). Then crane places stacks of steel on wrappings spread over first of a series of gravity roller sections. Gravity rollers convey bundles through banding area (right, above). Then, through weighing, hydraulic line alongside gravity conveyors operates control brakes at work stations.

production at Weirton Steel Co.

Weirton Steel Company's big new Logan conveyor line shows what conveyor design *can accomplish*. The 375-ft. system is made up of successive sections of Logan electric and gravity rollers teamed with overhead cranes to match the variable pace of Weirton's strip steel bundling operation. The result: seven men now easily prepare four times as much steel for shipping as 26 men could before! Details of the installation and Logan's Plant Dynamation technique are shown and described on these pages.

Logan conveyor design helps harness ***all*** *the work-power potential of your plant*

A major key to output for any plant is the unique pattern and pace of its potential work flow.

To exploit this "dynamic principle" of a plant—to put *all* its productive energy to work—*one right* custom-designed conveyor is required.

The Logan technique of Plant Dynamation insures this one right system for your plant. The Logan engineer works with you through a complete analysis; then section by section he designs and specifies the complete conveyor *dictated* by the dynamics of your operation. Your plant may call for maximum or partial automation.

Over the half century in which assembly-line production itself has grown up, Logan engineers have proved and extended their exclusive Plant Dynamation technique. For example, in your area "The Man from Logan" is one of a group with an average of fourteen years of this vital experience.

Only a complete-line conveyor company like Logan has the wide range of products to back up Plant Dynamation. To give your plant its *one right* system, the Logan engineer specifies freely from one of the industry's most comprehensive lines of conveyor equipment. The Logan engineer commands five distinct power modes: gravity, electricity, hydraulics, pneumatics, and control electronics.

"The Man from Logan" stationed near you is quickly available. This qualified specialist in Logan Plant Dynamation works directly with your engineers through design and installation to smooth operation. Write or phone today for a conference on the dynamic possibilities of your plant.

Logan Conveyors

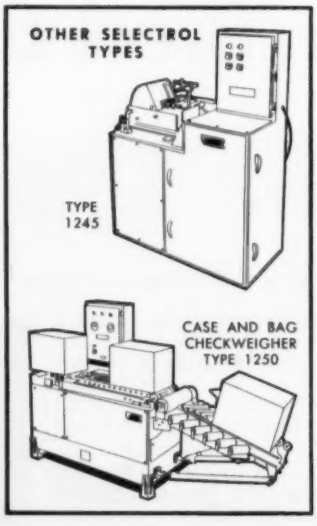
LOGAN CO., 218 CABEL ST., LOUISVILLE 6, KY.

Circle 672 on Page 19

New Automatic Checkweigher

Signal lights and counters for control and adjustment of filling or processing machines are available as optional equipment.

SELECTROL® offers accuracies of 2/10 of one percent



This new Selectrol Checkweigher, Type 1206, sorts either closed or open packages and permits trimming of rejects. Operating speeds up to 120 weighings per minute; accuracies of 2/10 of one percent of the product weight. Greater speeds are possible at lower accuracies . . . and greater accuracies at lower speeds. Operation is completely automatic. Tolerances are adjustable.

Selectrols are made by Exact Weight, a manufacturer of scales for 45 years, with experience gained through hundreds of checkweighing installations during the past 18 years in 28 states and in foreign countries.

Write for Bulletin 3377.

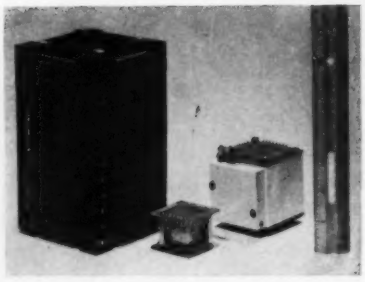
Exact Weight SCALES

THE EXACT WEIGHT SCALE CO.
907 W. FIFTH AVE., COLUMBUS 8, OHIO
In Canada: 5 Six Points Road, Toronto 18, Ont.

Sales and Service Coast to Coast

Find us in your local 'Yellow Pages'

BETTER QUALITY CONTROL . . . BETTER COST CONTROL



MANUFACTURING technique developed by General Ceramics Div., Indiana General Corp., for the fabrication of ferrite core memory devices permits drastic reduction in the size of these components. Procedure involves inserting drive lines through the memory planes and then folding the planes, thus eliminating conventional frames and all solder connections between planes. Photo illustrates (left to right) a conventional stack of twelve 16 x 16 core planes; a core stack of equivalent capacity made by the new process; and a model of the new-type core stack equipped with imbedded temperature control thermistors and external, insulated heating pads. Switching times for the new units range from 2.6 to 0.5 microsecond.

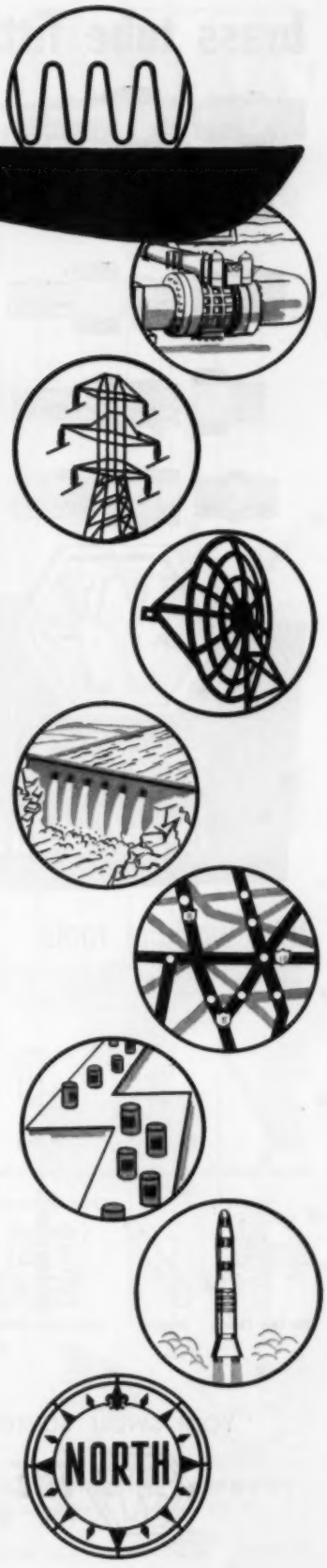
equipment to industrial users. The plant, located in Bradner, Ohio, will have complete facilities for commercial testing. Products will include furnaces for temperatures exceeding 1000 F. . . . **Continental Conveyor & Equipment Co.** has completed purchase of the Industrial Div. of Continental Gin Co. Conveyor service, replacement, and repair will continue to be offered for existing installations. . . . **Farrington Mfg. Co.** has acquired Adrema Ltd., British manufacturer of business machines and systems. . . . **Minnesota Mining & Mfg. Co.** has announced plans to construct a 14-story administration building as the latest step in a long-range plan to provide research and administration facilities on a recently acquired 265 acre tract near St. Paul. . . . **American Brake Shoe Co.** has announced the acquisition of Raymond Atchley Inc., manufacturer of electrohydraulic and electropneumatic servo control equipment.

MEETINGS AND EVENTS

Feb. 14-18—

American Institute of Mining, Metallurgical, and Petroleum Engineers. Annual Meeting to be held at Statler-McAlpin Hotel, New York. For further details contact

our business is communications and control systems...



For over 75 years North Electric has been designing, engineering and manufacturing "systems" designed on the dual functions of communications and control.

Today, North Systems speed man's thoughts and words over vast distances, between continents and over oceans in seconds.

Today, North Systems control the flow of light, heat, power and water for homes and industry, petroleum products for the wheels of America and chemicals for industry.

Today, North Systems are at work on land, sea and in the air as integral cogs in our vast transportation network.

Today, North Systems make possible high speed data processing complexes functioning through highly efficient switching centrals.

Today, North Systems automate production tools and production lines, handle packaging and pricing chores, perform scientific testing, measuring, weighing and analysis, and hosts of similar functions.

Today, North Systems help BMEWS guard our frontiers, add to our missile capability in projects THOR and JUPITER and help keep our nation safe and strong in many other defense programs.

At North Electric, the engineering team represents a cadre of professional competence with the solid background that comes from long experience in the application of system concepts.

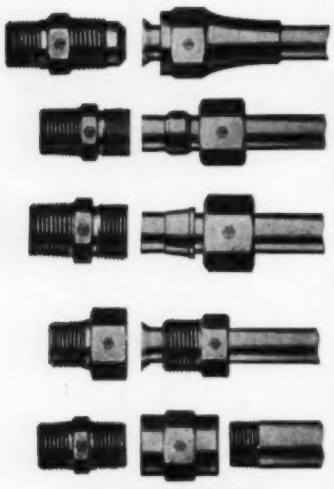
To learn what North can do for you, systemwise, today and tomorrow, write for your copy of "North System Concepts" booklet—now.

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

622 S. Market St. *Galion, Ohio*

brass tube fittings



S.A.E. 45° FLARE
USE with copper, brass, aluminum, steel and plastic tubing. U.L. listed; A.G.A. approved. Meets SAE Hydraulic standards and A.S.A. and A.S.M.E. codes. PRESSURE RATING: up to 3000 p.s.i. Sizes: ⅛" to ¾".

COMPRESSION
USE with copper, brass, aluminum and plastic tubing. U.L. listed; A.G.A. approved. Meets SAE Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes. PRESSURE RATING: up to 2000 p.s.i. depending on O.D. of tube. Sizes: ⅛" to ¾".

SELF-ALIGN®
USE with copper, brass, aluminum and plastic tubing. No flaring, soldering, welding, or special tube preparation needed. PRESSURE RATING: up to 2000 p.s.i. Sizes: ⅛" to ¾".

INVERTED FLARE
USE with copper, brass, aluminum, steel and plastic tubing. Meets SAE Hydraulic Tube Fittings and A.S.A. and A.S.M.E. codes. PRESSURE RATING: up to 3000 p.s.i. Sizes: ⅛" to ¾".

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USE with brass or steel pipe. Meets specifications of SAE TPHL Fittings Committee. PRESSURE RATING: up to 5000 p.s.i. Sizes ⅛" to ¾".

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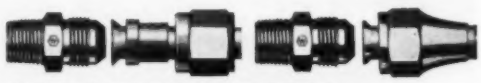
Most dependable high pressure fitting in the world . . . easiest installation. FOR FLARELESS TUBE SYSTEMS. No flaring, threading, welding or soldering. Available with carbon steel; stainless steel; cadmium plated or Weathercote finish. Standard Sizes: ⅛" through 2". Pressure Ratings: up to 10,000 p.s.i.



FLARE-TWIN HYDRAULIC TUBE FITTINGS
SAE 37° FLARE (J.I.C.) STEEL FOR FLARE TUBE SYSTEMS. No threading, welding or soldering. Two-pc. and three-pc. carbon and stainless steel with cadmium plated or Weathercote finish. Standard sizes: ⅛" through 2". Pressure Ratings: up to 10,000 p.s.i.

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Designed to make fast, easy work of every tubing job. We offer a complete line of low cost, quality made tools for cutting, bending and flaring tubing up to ¾" in O.D.

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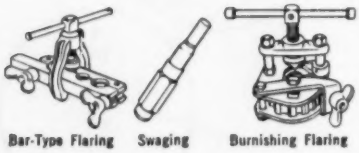

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H-25—High Pressure
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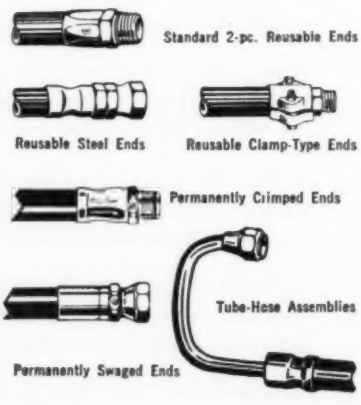
hose assemblies



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AIME headquarters, 29 W. 39th St., New York 18, N. Y.

Feb. 15-17—

American Management Association. Midwinter personnel conference to be held at the Palmer House, Chicago. Additional information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

March 6-9—

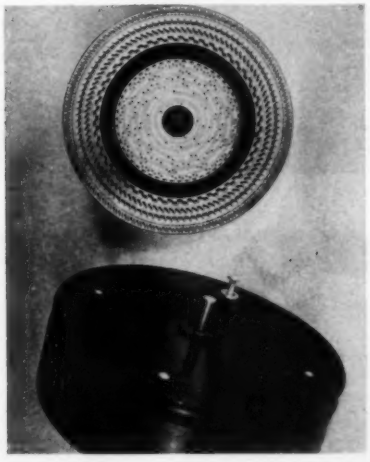
American Society of Mechanical Engineers. Gas Turbine Power and Hydraulics Conference to be held at the Rice Hotel, Houston. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

March 9-11—

Instrument Society of America. ISA Temperature Measurement Symposium to be held at the Deshler Hilton Hotel, Columbus, Ohio. Further information is available from William H. Kushnick, ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

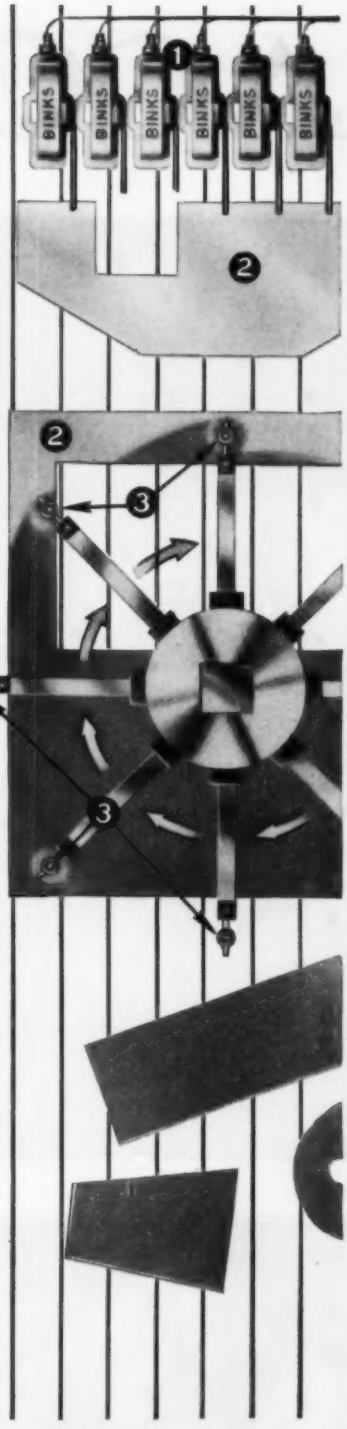
March 21-24—

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Additional infor-



IDENTIFYING any of 1000 parts of a single revolution by a distinct binary coded decimal output is the job accomplished by this shaft position encoder developed by Norden Div., United Aircraft Corp. Six-inch diameter analog to digital converter is applicable where decimal outputs are desired, as in machine tool control. Device includes internal, self-selecting brush logic.

Now you can automatically SPRAY non-repetitive, odd shapes without wasting material...



Binks MEMORY TIMERS automatically sense product shape, size and location on the conveyor and relay these data to your automatic spray guns. Spray guns operate only when each product is in precise position. No material is wasted spraying cutout areas or odd shapes. Coverage uniformity is improved.

These electro-mechanical timers are rugged and dependable . . . adaptable to most rotary, horizontal or vertical spraying machines.

Here is how the system looks from above

① *Binks MEMORY TIMERS astride your conveyor sense size, outline and location of...*
② *irregularly-shaped products to be sprayed and relay this information to . . .*
③ *your automatically operated spray guns.*

Send for Bulletin A96-1 See how this new timer completely automates your finishing operation without involving you in complex equipment. Call your nearest Binks Branch Office or write direct.

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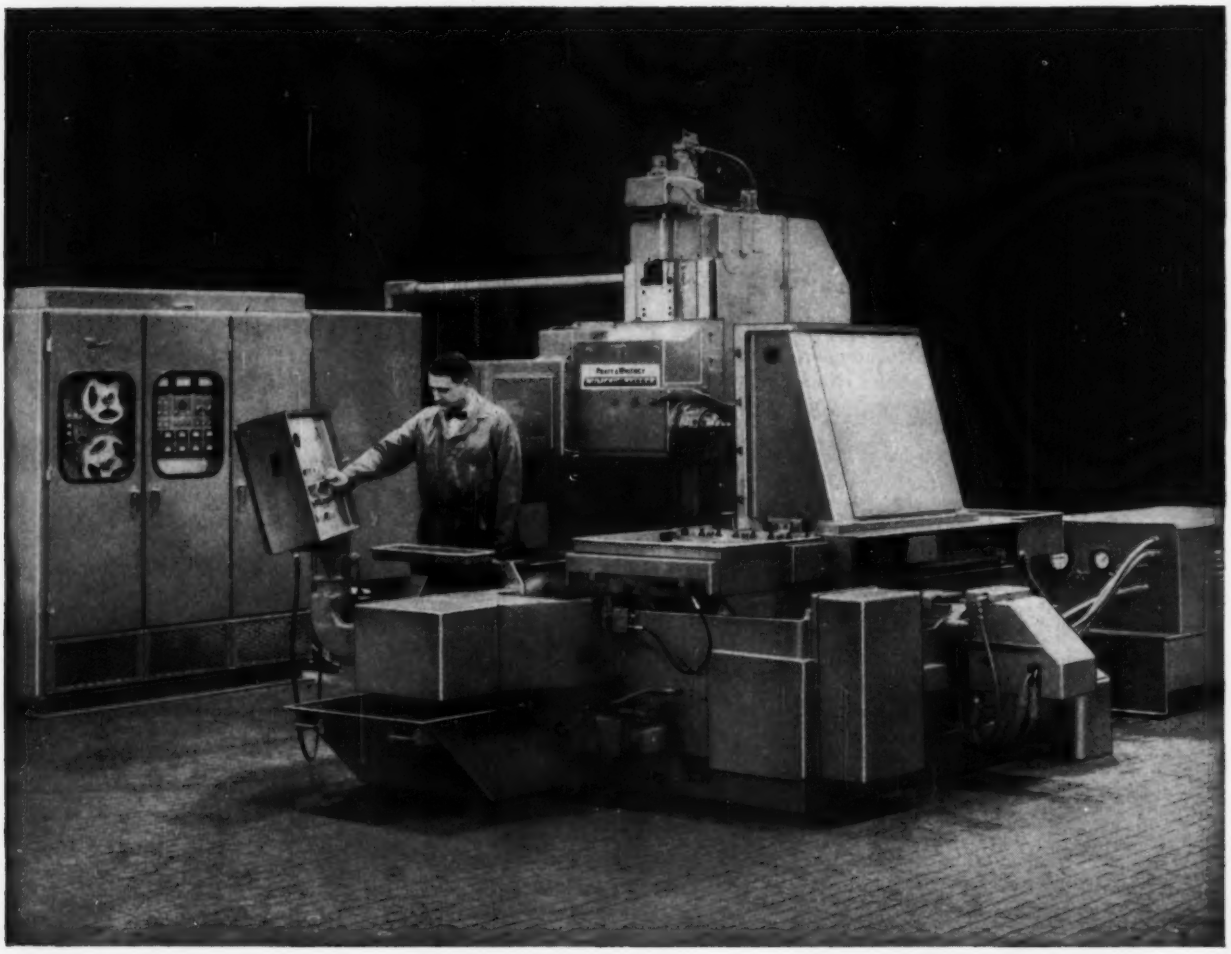
Circle 676 on Page 19

ACCURACY



PER-PIECE PRODUCTION TIME CUT 33% . . . by machining these aluminum computer housings on a Numeric-Keller. Each piece required 12 pockets milled and 72 holes drilled. Scrap loss to date: zero!

ONLY 21.5 HOURS . . . were needed to machine this complicated tool steel missile part on a Numeric-Keller. Machining involved 3 roughing and finishing contour cuts and 4 roughing and finishing pocket milling cuts.

3-DIMENSIONAL MILLING UNDER TAPE CONTROL . . . is demonstrated by this vision block for a super-modern military tank. Geometry is quite complex. Tape was prepared using both computer and hand computations.

ASSURED...

...PLUS REVOLUTIONARY ADVANCES IN MACHINING SPEED, EFFICIENCY and VERSATILITY with the new

NUMERIC KELLER

TOOLING COSTS and LEAD TIME CUT AS MUCH AS 75% . . . because the P&W Numeric-Keller is equipped for continuous-path milling under the direction of a tape-reading numerical control system. Models, templates and other costly, complicated tooling are eliminated!

EXTREME ACCURACY . . . with overall production easily held to ± .001". Piece-to-piece reproduction accurate to "tenths" is possible with controlled cutter selection.

UNUSUAL VERSATILITY . . . with more different types of jobs done faster and better. Short and long runs are handled with equal efficiency. Using tape, changeover is fast and easy, with minimum time lost between jobs.

MACHINE UTILIZATION IS GREATLY INCREASED . . . because more time is spent making chips, with less time needed for setup, fixturing and other non-productive operations. Similarly, man-hours are made more productive.

MACHINING TIME IS SLASHED . . . because tape control means maximum speeds and feeds programmed through all phases of the machining cycle. Optimum machining practice at all times also means finer surface finishes.

SEND NOW FOR THE CASE-HISTORY FACTS . . . that show how the P&W Numeric-Keller has saved *HOURS* of setup, tooling and machining time on dozens of jobs like the 3 examples shown on the facing page. See how this revolutionary machine can produce equally important savings on the toughest milling jobs in YOUR plant. Write today for your copy of Circular No. 624, that includes Job Analysis Sheets to give you the dollars-and-cents facts on Numeric-Keller savings. Pratt & Whitney Company, Inc., 35 Charter Oak Blvd., West Hartford, Connecticut.

100th Anniversary 1860 P&W 1960

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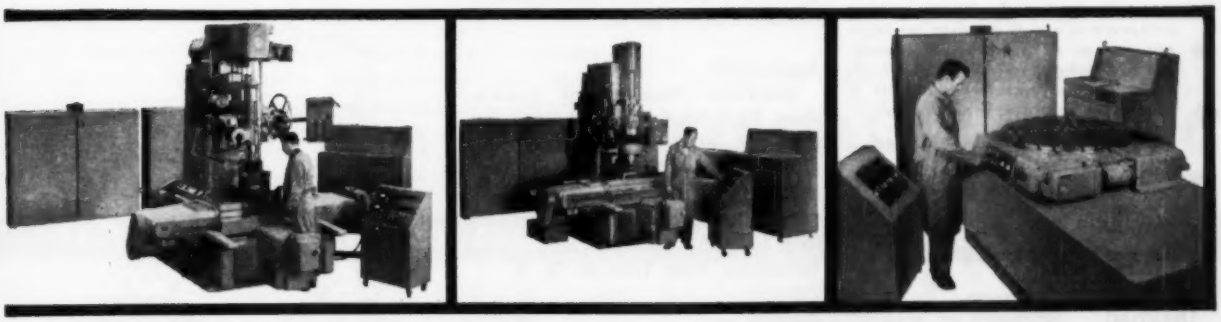
FIRST CHOICE FOR ACCURACY

MACHINE TOOLS • GAGES • CUTTING TOOLS



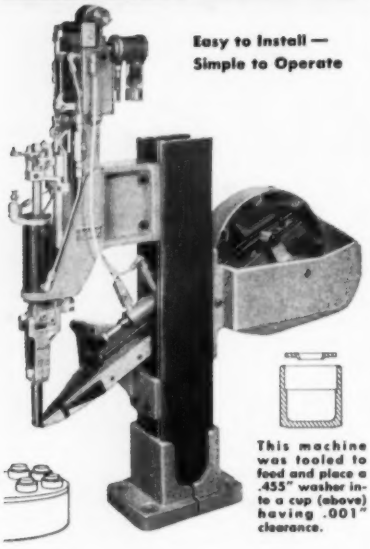
OTHER P&W NUMERICALLY CONTROLLED MACHINE TOOLS . . . include the Jig Borer, Vertical Precision Hole Grinder, and Precision Rotary Tables. Providing settings accurate to .0001", made automatically from data supplied by punched tape or operator keyboard, the Jig Borer and Hole Grinder combine toolroom precision with production-line speed and ease of operation. Equally efficient for short- or long-run production work. Ultimate in speed plus precision in circular spacing, graduating, and angular positioning, the Pratt & Whitney Numerically Controlled Rotary Table provides automatic settings accurate to 5 seconds of arc!

FOR TIMESAVING ASSEMBLY OF SMALL PARTS

DIXON

Auto-Positioner

IN FOUR STANDARD MODELS



Easy to Install — Simple to Operate

This machine was tooled to feed and place a .455" washer into a cup (above) having .001" clearance.

- *New Positive-Acting Feeder*
- *Automatic Sensing Device*

The Dixon Auto-Positioner is a compact, air-operated automatic assembly machine for parts from 1/16" to 2" size at speeds up to 6000 cycles per hour. It is furnished as a fully automatic station for use at a dial or in-line transfer table, or as a self-contained machine with pedestal and fixture table. There are four models, providing a selection of equipment to suit your requirements.

Dependable, Accurate, Compact

The new parts feeder is simple, compact (only 6 inches wide), and efficient. It provides positive advancement of the part into the chuck; it has a straight track and a positive-acting escapement; and it requires no separate motor or vibrator. Automatic sensing assures quality control. It interrupts the cycle when a part is missing or improperly assembled.

Standard Equipment, Easily Retooled

The chuck, positioning punch, and feeder tooling are easily modified or replaced for other jobs. Compactness permits close nesting at multiple stations, cutting cost of fixtures, dials, or transfer devices.

DIXON

Send for Bulletin AP-B2 or request our machine planning service.

DIXON AUTOMATIC TOOL, INC.
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Equipment for Automatic Parts Handling and Assembly

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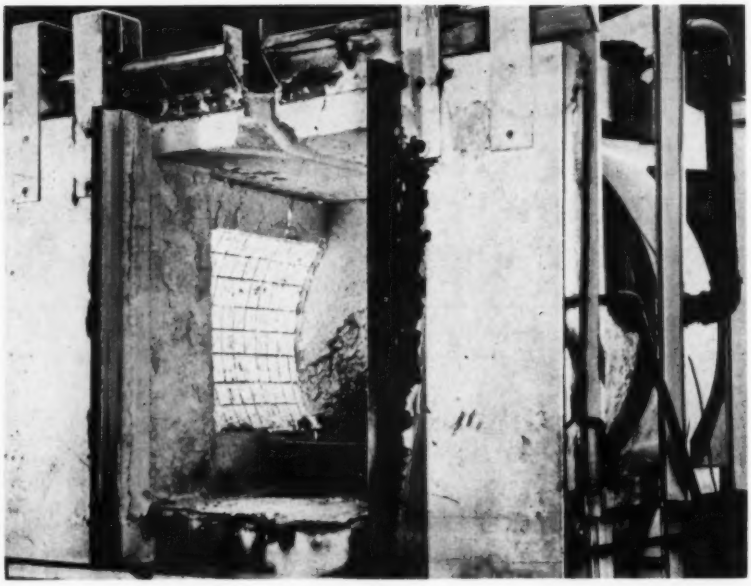


RAPID heating, cooling, and reheating are possible with this luminous wall heat treating oven developed by A. F. Holden Co. Controlled gas-air mixture passing through porous refractory lining ignites at face of lining, providing uniform radiant heat. Furnace can be heated to 2000 F within 10 minutes after ignition by a pilot. Cooling is effected by forcing air through the refractory lining.

mation is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 22-24—

Society of Automotive Engineers Inc. National production meeting to be held at the Statler Hilton Hotel, Cleveland. For further details, contact SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 29—

Material Handling Institute Inc. Spring Meeting to be held at Hilton Hotel, Pittsburgh. For further information contact W. L. Redding, Hanson & Shea Inc., One Gateway Center, Pittsburgh 22, Pa.

April 4-7—

American Management Association. 29th National Packaging Exposition and Conference to be held at Convention Hall and the Shelburne Hotel, Atlantic City, N. J. Additional information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

April 5-7—

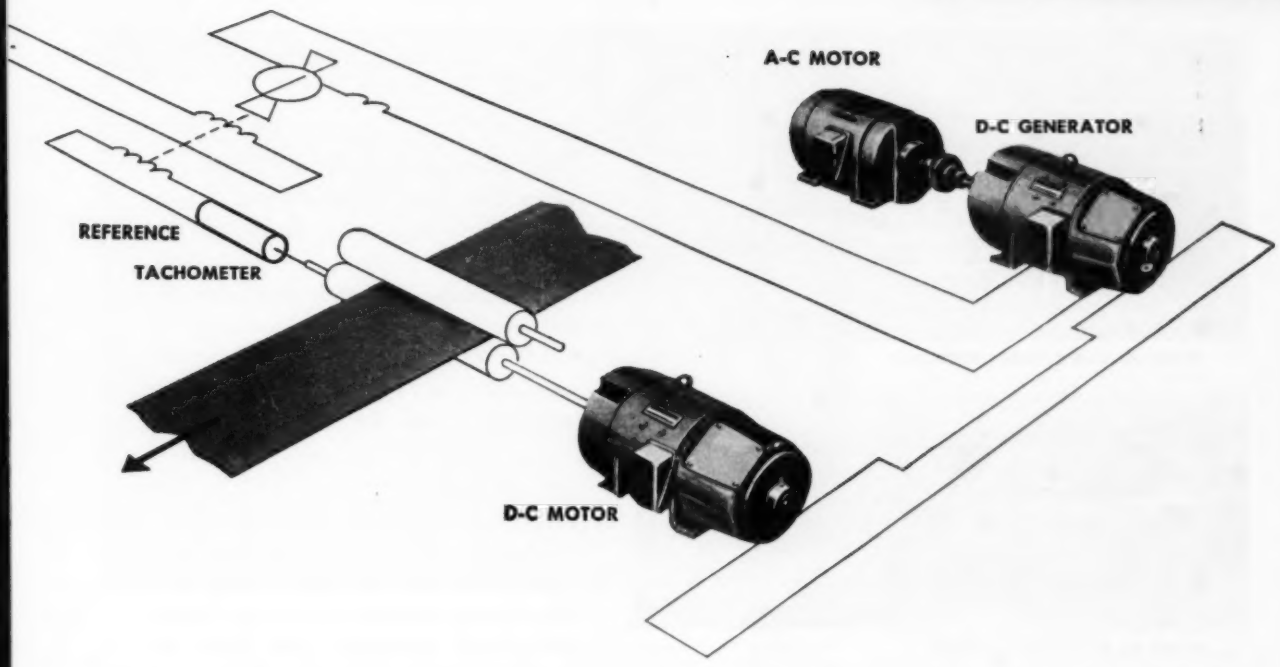
Instrument Society of America. Third National Chemical & Petroleum Instrumentation Symposium to be held in Rochester, N. Y. For additional details contact Director of Technical and Educational Services, ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

April 11-13—

Fourth Conference on Manufacturing Automation. Co-sponsored by Purdue University and AUTOMATION magazine, conference will be held at Purdue University, Lafayette, Ind. For additional information contact K. E. Glancy, Div. of Adult Education, Purdue University or AUTOMATION, Penton Bldg., Cleveland 13, Ohio.

"I tell you, this automation of his is going to put us all out of work."

D-C DRIVES FOR PRECISE CONTROL



Problem: How to obtain precise control of machine speeds without human direction

Automation's most important requirement—*self-control*—enables machines to process work continuously with minimum human effort. This is why the trend to continuous automatic processing is a trend to direct-current drives. *For d-c can best supply the precise regulation and self-control that enables a machine to correct its own errors without human direction.*

Feedback—the heart of automation—compares machine output with pre-established standards. Deviations are corrected automatically, instantaneously. This is just one example of d-c's modern capabilities.

If you are seeking more automatic, lower cost means of production, it will pay you to investigate direct-current drives. A new booklet, "WHY D-C?", written for modern industry's management team, is available to help you. For your free copy, write ***Section 829-4, General Electric Company, Direct Current Motor and Generator Department, Erie, Pennsylvania.***

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MOTORS AND GENERATORS

POWER UNITS AND CONTROLS

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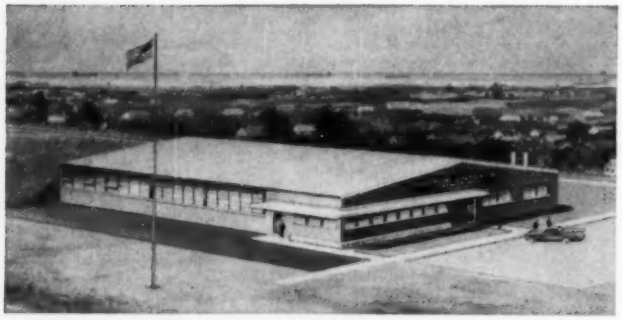
ANOTHER EXPANSION to Better Serve Industry in the Soaring Sixties



PLANT No. 4—ELK RAPIDS, MICHIGAN

PLANT No. 2—DETROIT, MICHIGAN

PLANT No. 3—MANCELONA, MICHIGAN

The recent opening of our Plant No. 4 in Elk Rapids, Michigan, marks the fourth expansion in our manufacturing facilities since we set up in business 35 years ago. In the intervening years, we have earned an international reputation for designing and building money-saving machine tools for many types of industries. We have also diversified our engineering and production talents so that our machines, which originally were specialized in metal-cutting operations, now reach into the nuclear power, electronic, chemical, drug, cosmetic and food industries and are used in processing many household products in everyday family use. To the many people who have helped us build this business, we say, "Thank you, sincerely."

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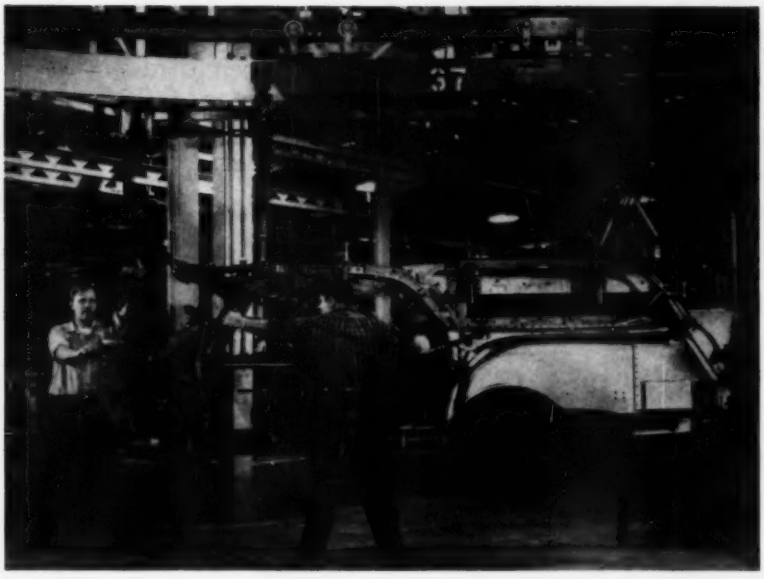
PLANT NO. 1—DETROIT, MICHIGAN

Circle 680 on Page 19

By JAMES C. KEEBLER Managing Editor



This is one of the 64 side gate fixtures used in the body framing operations at the Plymouth Detroit assembly plant. Actually giant clamps, such fixtures provide a close fit for sides, floor, and roof during welding. Fixture shown clamps the side panel of a station wagon.

More Automatic Operation

ONE of the criticisms that has been expressed about automation is that those who write about it tend to overglamorize the "miracle making" aspects of automation developments. Although authors whose writings appear in technical journals cannot claim total immunity from this malady, they generally do a more healthy job than is exhibited in the "popular press."

Much to Expect

Under such banners as "Completely Automated Plant Opens Here" the story may often leave the reader with the erroneous impression that the workerless factory is a cold reality and the manufacturing engineers of this nation have reached the end of their ingenuity.

The extreme to which this misconception can go was ably expressed by the almost tearful disappointment of a German journalist who had come across the pond to see an automated engine plant and found to his dismay that the plant of his choice employed 4000 people whereas he had expected the buildings to be uninhabited. Admittedly these expectations were based upon what he had read about the place and his evaluations were subject to his understanding of the meanings of the words that had been used to describe this plant and similar installations.

Such an incident leaves a lasting impression and prompts some of us to steer clear of the use of such words as "ultimate in," "completely," or "fully" to modify the word automation.

One can rationalize the position of the less sophisticated reporters whose training points their collective noses to sniff out the sensational. More often than not it is to no one's advantage to hang the dirty linen that reveals the sordid side of a particular development. The tries that failed, the bugs in the system, the compromises with reality, the mundane months of preplanning, planning, waiting for approvals, designing, building, and debugging are either glossed over as insignificant or omitted in an effort to portray the positive side of the material. The result can easily be a published account of what reads like a modern miracle.

Because in any case the author tells only what he chooses to reveal, or slants his presentation to achieve a particular impression, the resultant writing can at best be considered but an excerpt from the total "life facts" of the complete circumstances being reported.

Although some of this nation's technical minds look with great disdain upon the popular misconceptions concerning automation, some of these same minds may have contributed to this delinquency by releasing their theorems as bare hypotheses and conclusions, while omitting the painful procedures that constitute the steps of the proofs.

Hard to Compare

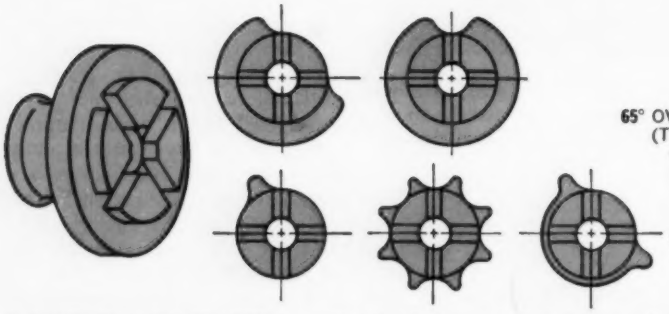
At this stage of development of the art it is also only fair to note that the layman has still not been furnished any rational common denominator system with which to compare degrees of automation. It is still like trying to decide who is the most highly educated man in the corporation—some appear more so than others but usually in different ways.

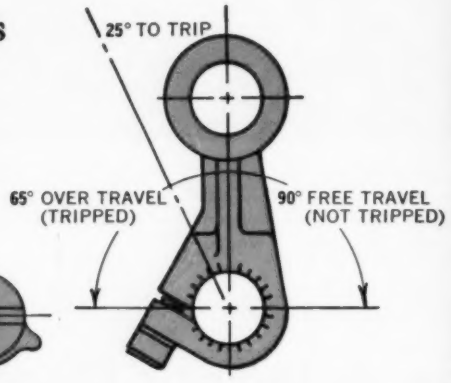
In this regard it would be well to occasionally remind the populace

The SL2 snap-lock•Newest NAMCO Machine Life Limit Switch

Snap-Lock Limit Switches, developed by National Acme to meet their own rigid specifications, have become industry's standard for reliable "machine life" service. Latest and most advanced in the complete line is the SL2. Built with typical machine tool precision and ruggedness, it will give millions of consistently fast, accurate contacts. Further, it is completely water and oiltight and has the heft to stand the bruising conditions imposed by heavy-duty machine applications. You owe it to yourself to closely examine the *combination* of performance characteristics that assure completely reliable limit switch performance under the most extreme operating conditions.

Closely Check These Outstanding Features





1. Infinite Operating Flexibility . . . One simple interchangeable cam controls contact sequence . . . performance can be tailored to the specific needs of each application.

2. Ample Overtravel and By-pass . . . Sixty-five degree overtravel . . . 90° by-pass . . . 180° arc.

3. Clockwise or counterclockwise motion . . . Converting from clockwise to counterclockwise motion takes but a few seconds . . . no tools required.

4. Light operating pressure . . . Tripping action is 50% less than previous models. Overtravel action requires only 8 pounds at 1½ inch radius.

5. Shock-proof Mechanism . . . Positive mechanical lock . . . prevents accidental movement due to shock or other external causes.

6. Faster Contact Action . . . Make and break speed up to 50% faster than predecessors . . . assures foolproof operating and wards off destructive arcing.

7. Greater Contact Pressure . . . Contact bounce minimized by use of new contact material that permits four times greater contact pressure.

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MADE IN U.S.A.
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that, despite any impression they may have gained to the contrary by reading true accounts of accomplished facts, it still takes a lot of time, money, and engineering ingenuity to devise, install, and operate a manufacturing facility that is only modestly more automatic than previous facilities. And this technology is what most of us have come to recognize as automation even though the net result might not be as automatic as one might imagine.

Difficult to Transform

The complexities of the problems encountered while going more automatic, and the time and economic limitations placed on the pace of this transformation can be seen by observing operations in an assembly plant. Bare statistics of modernization may be misleading. A case in point is the Plymouth assembly plant in Detroit built in 1928.

Prior to the recent 21-month modernization program in what the plant manager, Kenneth Crawford, dubbed "the most mature auto assembly plant in the industry" this plant could boast two assembly lines rated at 90 per hour for a plant capacity of 180 per hour. Now there is but one line going at 60 per hour. Other assembly plants in dispersed geographical locations make up the difference in schedule and produce closer to the marketplace. A longer cycle time enables the line to build better quality, reducing costly off-the-line repairs.

A total of 146 overhead conveyors were removed and replaced by 127 new ones. The plant's 27 miles of conveyor were cut to 21 miles. Old final assembly lines were 1000 feet long, new one is 1972. This big checker game involved the addition of 57,000 square feet of floor space, and revamped to a marked degree the products made herein. The new model is a unitized body which is all assembled here instead of being brought in assembled from the Mack Avenue Plant as was formerly the practice. Whereas 25 per cent of the floor space of this plant was used to machine and assemble six-cylinder engines, these operations were moved to the Trenton Engine Plant.

Quality to Build

They don't make 'em like they used to. They make 'em better. The "gate line" method of body construction is used.

Gates are suspended from overhead rail conveyors. Side members and panels are clamped in the required location in the gates. Right and left-hand gates move around their respective loops and meet a straight line of framing base trucks pulled by a floor conveyor. As the gates are locked onto the floor trucks auto underbody parts are positioned on the trucks and meshed with the sidebody stampings on the gates.

The gates remain locked to, and move with, the floor trucks until the roof and other members are welded together in order to complete the structural body. After the welds are made the gates are unclamped and return on overhead rail loops to be reloaded. The trucks take the bodies to further welding operations and the bodies are then transferred to soldering and grinding operations which are performed with the body mounted on a simpler truck that will take it through to the paint operations.

Body soldering is a craftsman's art and requires skilled hands, but the sorting bank after this operation and prior to painting is highly automated. Sequence on the body build line is by body style, but sequence in the painting lines is by color. Each lane of the storage bank has a different body style. The paint conveyor dispatch operator can release the various styles in such a sequence as to establish color groups. This is done at a pushbutton control console. Painting is accomplished by Chrysler's new rustproofing process.*

A similar automated bank after the paint operation permits release of bodies to the body hardware line in a mix that achieves production efficiency by use of the least number of operators on the ensuing assembly operations.

At the start of the main "gate line," the sides of a car body are swung into position in their fixtures and clamped to the floor pan. Moments later the roof will be placed and the body welded together. This photo shows the operation taking place at the Plymouth Detroit assembly plant.

Automated to a Degree

Much of the work performing, handling, and control equipment used in this plant is of a higher order of automation than was formerly used, and as such it can be called an automated plant (although it is not publicized as such by its management).

Yet, lest anyone be deluded into thinking of this as a workerless automaton, it should be reported that the place employs in excess of 5000 people.

*See "Wanted by the Public," AUTOMATION, Vol. 6, No. 11, Nov. 1959, p. 45.

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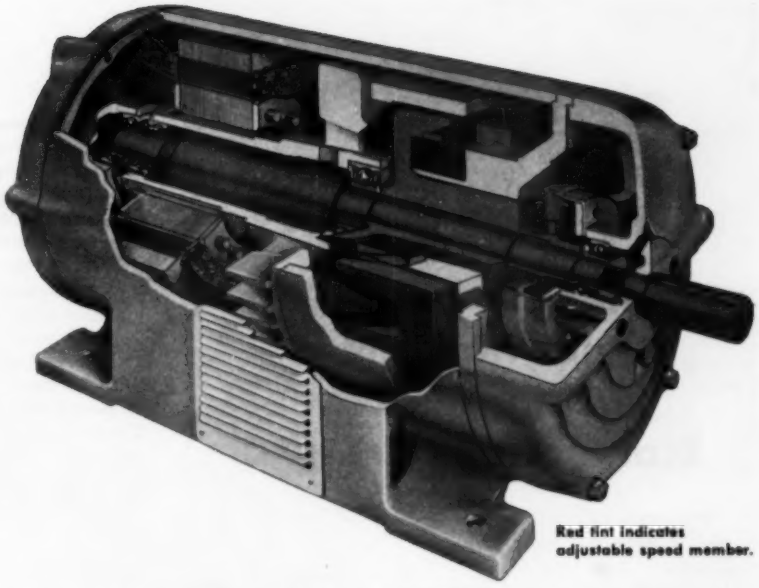

Red tint indicates adjustable speed member.

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Three compact components, the Ajusto-Spede Drive, the K-2 Control, and the push-button station make up this complete drive package which provides controlled adjustable speeds for any application from ½ HP through 7½ HP at 1800 RPM.

Remote wall mounting of the control panel conserves space on the driven machine; the push-button station places vital controls at the operator's finger tips.

Standard control features include on-off clutch control, infinite speed adjustment, constant speed regulation, and jogging. Any of a variety of special features may be easily and economically added to the standard control by the installation of a single resin-encapsulated circuit.

Send for complete information covering design and operation of the new models ACM-903 and 904 Ajusto-Spede Drives. Read how the new K-2 Control provides infinite speed adjustment, on-off clutch control, constant speed control, jogging, threading, cascading, and acceleration control.

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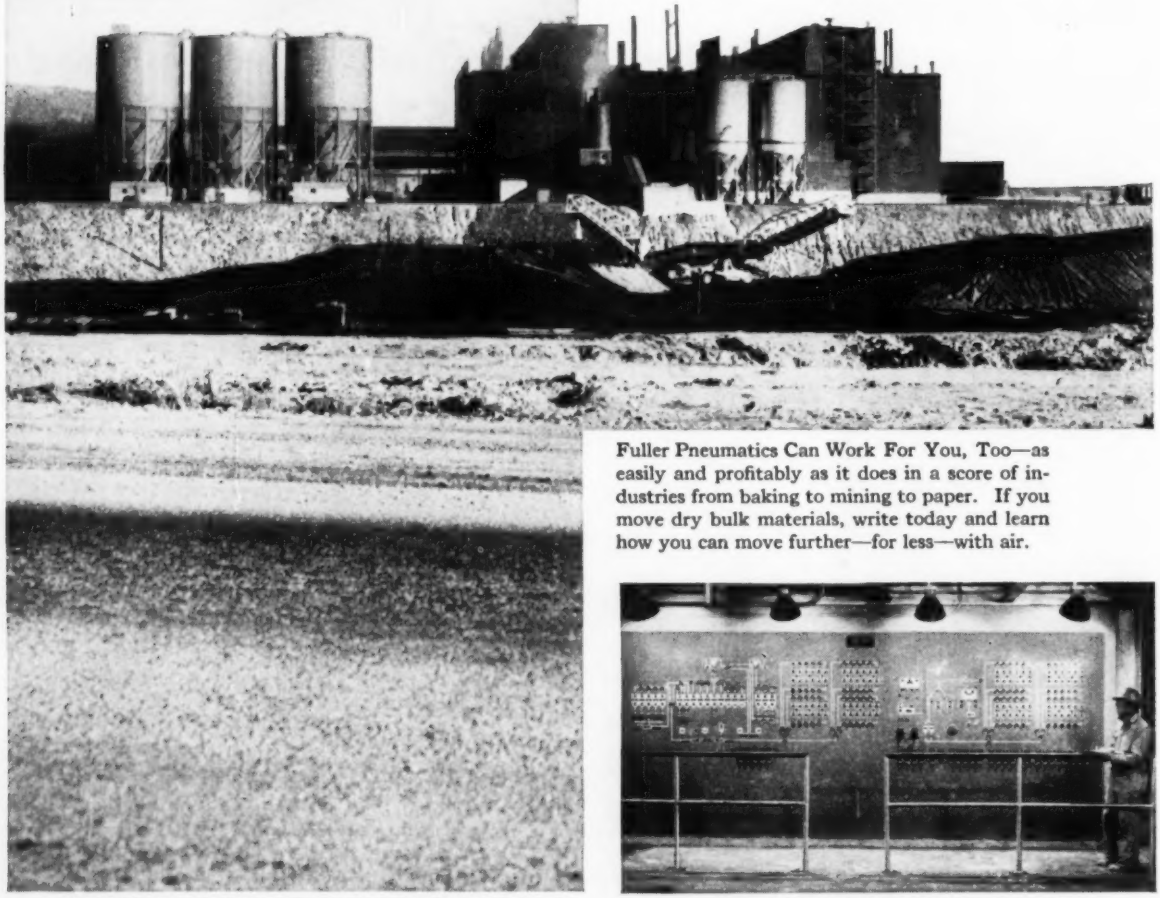
Circle 682 on Page 19

How Pneumatic Conveying Helps Make New Mining Process Economically Practical

Taconite processing is typical of the many varied, cost-saving applications for Fuller Pneumatic Conveying.

They're turning low assay iron ore into rich pellets on the Mesabi these days. Moving additives for pelletizing, Fuller plays a special role in this feat of engineering and production economy.

Fuller Pneumatic Conveying Systems are carrying fine anthracite screenings, soda ash, and bentonite from siding to storage to processing—with speed, safety, sanitation, and efficiency. With few moving parts to wear out and powered by inexpensive low-pressure air, Fuller Pneumatic Conveying Systems speed dry bulk materials *anywhere that a pipeline can be run:* under ground, up through floors, around corners . . . for far greater distances and at substantially lower cost than possible with mechanical conveyors.



Four Fuller Pneumatic Systems can speed more than 307 long *tons* of additives through this huge Taconite Pelletizing Plant in a single day.

Fuller Pneumatics Can Work For You, Too—as easily and profitably as it does in a score of industries from baking to mining to paper. If you move dry bulk materials, write today and learn how you can move further—for less—with air.

Centralized control is provided by giant panel designed and manufactured by Fuller.

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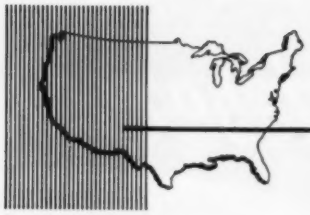
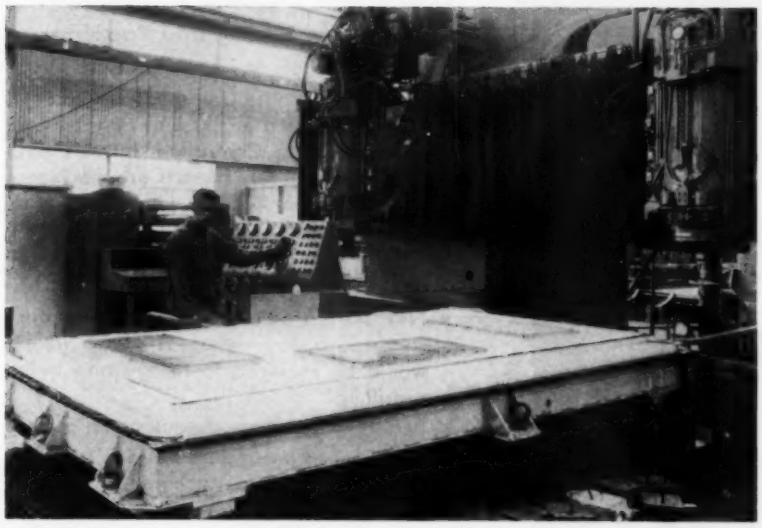


western trends

By PATT PATTERSON
Los Angeles, Calif.



PUNCHED CARD controlled skin mill at Rohr Aircraft Corp. is used to machine stainless steel honeycomb core stock in both simple and compound configurations. The machine bed measures 8 by 30 feet. A novel type of freezing chuck recently developed by Rohr holds the honeycomb stock during machining. In addition to this machine, Rohr has eight other numerically controlled machine tools in operation.

Production Time Savers

NUMERICAL CONTROL as an automation technique has proved its practicality and flexibility in numerous machine applications for accomplishing automatic drilling, boring, grinding, milling, forming, cutting, welding, and riveting. The application of electronic control equipment to manufacturing machinery has opened new avenues to economy and uniform quality of product, and Western aircraft and missile manufacturers have taken a leading role in developing and utilizing this advanced technique in controlling production processes.

For example, Rohr Aircraft Corp., Chula Vista, Calif., is taking a leading role in the application of numerical control to the production of complex aircraft parts—particularly in the employment of tape and card controlled machines in the milling of hard steels. The company now has in operation or in the process of installation five Morey vertical profiling machines operated by Electronic Control Systems machine control units, a Giddings & Lewis horizontal profiler controlled by one-inch wide magnetic tape, two punched card controlled Cincinnati skin mills, and a Cincinnati horizontal profiler operated also by punched cards. Also recently installed is an Electronic Control Systems Digimatic director which is used in the preparation of magnetic tapes.

The tape controlled Morey profilers are among the first numerically controlled machines developed for machining of hard steels. For example, one of the parts produced on this machine is an intricate AISI 4340 steel yoke (similar in appearance to the old time oxen yoke) that will be used to mount jet engines to Lockheed's Jetstar. When it reaches the machine, the part is in the shape of a rolled plate billet, and during machining, over 800 pounds of metal are removed. The Moreys also have been producing "duck bill" mid spar fitting parts for the Boeing KC-135 jet tanker.

Numerical control specialists at Rohr feel that the greatest application for electronic controlled equipment is in the general purpose machine tool field. Major advantages cited are better finishes on machined surfaces, reductions in tooling costs and machine time, and reduction in lead time. In some types of manufacturing, the numerically controlled machine can reduce tooling costs by eliminating entirely the need for time-consuming model making.

Tape Controlled Welding

Another user of numerically controlled equipment in the aircraft industry is Convair, a division of General Dynamics Corp. For example, in its Pomona plant Convair is employing a tape controlled multiple-torch Heliarc spot welding machine developed by Linde Co. to produce parts for Terrier surface-to-air guided missiles.

Problems arose in the production of some Terrier parts, such as folding and dorsal fins, because the parts could be welded from only one side. There are 472 welds on the folding fins and 692 welds on the dorsal fins.

The welding machine uses four torches to cover a working area of 20 inches by 80 inches. In the Terrier application, four parts are welded simultaneously, and each torch can be positioned along *X* and *Y* axes encompassing an area 20 inches square. The geometry of the two fins required adjusting the workpieces so that they are normal to the electrodes at all times. Therefore, a work-support platen was designed that automatically

Tooling Cost Reduced 90% and BURGMASTER tape controlled

The Tape simultaneously positions the work on the X and Y axis at the rate of 150" per minute, selects the proper spindle, and controls all machine functions to produce parts automatically to close tolerances.

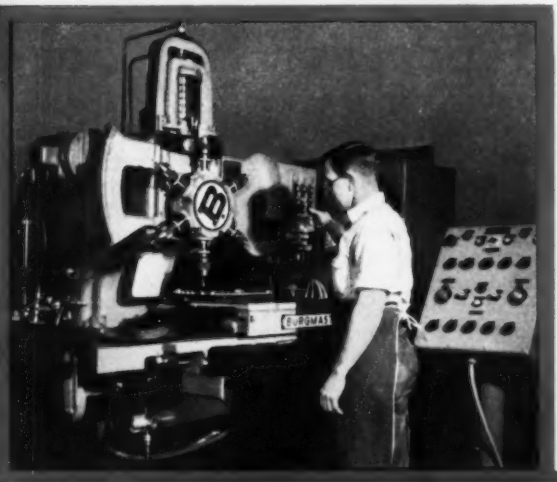
Tooling costs are reduced from $300 to $25 on this electronic part. 2-4 set-ups each 8 hours are made for small lot work of 1-20 parts holding ±.002" tolerances.

Maximum Flexible Automation---

For Drilling, Boring and Tapping Small Lots.

At The Collins Radio Co., small lots of 1-20 parts are handled easily and quickly with Burgmaster Tape Controlled Turret Drills. Normally, 2-4 different parts are machined each 8 hours to ±.002" with a minimum loss of time and tooling.

- Simple clamps are substituted for drill jigs.
- New parts are programmed, tapped and run in ½ a day—whereas 3 to 5 weeks would be required to design and build a drill jig.
- Resulting delivery schedules are better.
- Scrap losses are reduced due to Reliability of Controls and Machine.
- Surer, faster production is assured because the Burgmaster is automatically tape controlled for fast, accurate machining cycles.
- Scrap losses are reduced to Reliability of Controls and Machine.



World's Largest Builder of Turret Drilling Machines

"0" Manual Power Index ¼" Capacity

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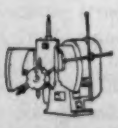
2B Manual Power Index ¾" Capacity



2BF Flange Mounted Power Index ¾" Capacity

2BH Automatic Hydraulic ¾" Capacity

3BH Automatic Hydraulic 1½" Capacity

2BR Ram Type Radial Drill ¾" Capacity

2BHT-3BHT Automatic Tape Controlled ¾" and 1½" Capacity

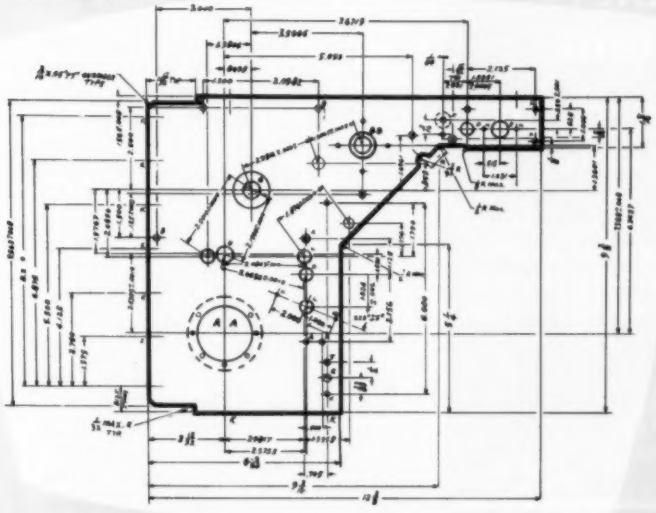
Maximum Flexibility for Small Lots

6 SPINDLE TURRET DRILL

(At Collins Radio Company, Cedar Rapids, Iowa)

Tremendous tooling reductions, time savings and better delivery schedules on small lots are the advantages experienced by Collins Radio Company, Cedar Rapids, Iowa, with their Burgmaster 6 Spindle Tape Controlled, Turret Drilling, Tapping and Boring Machine.

Normally, 2 to 4 different parts are machined each 8 hours in quantities of 1 to 20 pieces. The part shown required 44 C'Drilled holes and 31 holes of 5 different diameters. It was programmed, taped, checked and ran in ½ a day to tolerances of ±.002". Formerly, on standard drill presses, a drill jig costing approximately $300 would be required and take 3 to 5 weeks to design and build. Parts are held by simple clamps on a disposable 1" paper base phenolic laminate block, positioning the part against steel pins. Table positioning is 150" per minute, being automatically controlled by tape to accurately locate the work on two axes simultaneously for each of the 71 settings. The tape also controls the selection of proper spindle sequence and all machine functions. In addition, all standard adjustable Burgmaster controls are maintained including pre-selective spindle speeds, infinitely variable pre-selective temperature compensated feeds, selective rapid approach and return, and preset depth stops.



Because the Burgmaster Tape Controlled Machines produce so economically with exceptional tooling cost reductions and time savings on small lot work, *two more machines* have been purchased.

There is a Burg Tool representative near you—Call him for information on your work—there is no obligation.

Job Facts

Machine:	Burgmaster Model 2BHT 6 Spindle Turret Drilling, Boring & Tapping Machine with G.E. Tape Controls. Table Size 15" x 26".
Company:	Collins Radio Co., Cedar Rapids, Iowa.
Part:	Electronic Part 9⅞ x 9.563 x ¼"
Quantity:	20 per lot (typical)
Tolerance:	±.002" closest required
Holding:	Steel subplate on table, part held by simple clamps on disposable 1" paper base phenolic laminate. Parts positioned against steel pins.
Operations:	C'Drill 44 holes, Drill 31 holes (5 different dia.)
Former Method:	Standard Drill Presses and Drill Jigs.
Former Drill Jig Cost:	Approximately $300 requiring 3-5 weeks to design and build Programming and making tape: $25
Advantages:	Tool Savings $25 instead of $300, Max. flexibility—Normally run 2 to 4 different parts in each 8 hours, Savings in time resulting in a better delivery schedule and less scrap loss.

Write for Bulletin describing Burgmaster 6 and 8 spindle Tape Controlled Turret Drilling, Tapping and Boring Machines. See Burgmaster Machines in action: Forty-minute 16mm sound film showing all Burgmaster Turret Drills in operation is available from any Burg office without charge.

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Circle 684 on Page 19

Last Word In
TAPE READING NUMERICAL CONTROL!

PRATT & WHITNEY NUMERIC-KELLER

IT USES BEAVER BALL SCREWS TO OBTAIN A NEW HIGH DEGREE OF EFFICIENCY IN 3 DIMENSIONAL MILLING

This new machine tool cuts production lead time costs as much as 75%, automatically detects errors and compensates, permits tool change without loss of synchronization and offers many other features.

Table travel is 36" horizontal, 12" traverse, vertical slide moves 22"—and all movements are precision accuated by Beaver Ball Screws, first choice of machine tool designers.

Can our engineers help you obtain

(1) greater accuracy in positioning
(2) minimum break-away friction
(3) greater system stiffness

Beaver engineers are ready to work with you on your actuating problem.

Beaver Precision Products INC.
CLAWSON, MICH.

tilts the workpieces to the required positions along a Z axis.

A punched tape program control unit provides intelligence to the machine for establishing the X, Y, and Z locations for each weld. In addition, the control selects the combination of torches to be used at each distinct step in the welding program, as well as the desired time and current at each step. Output of the machine is 2520 spot welds per hour on the Terrier fins. This figure includes time for loading, positioning, welding, and unloading.

Another example of Convair's interest in numerically controlled equipment can be found in its San Diego plant. Here, the company has installed a tape controlled drilling machine that has a work area of 200 inches by 108 inches. Accuracy at any point in the work area is said to be within 0.005 inch.

Built by McKay Machine Co., the machine offers a range of three drill units which permits the drilling of three different sizes or styles of holes in a single drilling sequence. It is equipped with air drills, but electric turret-mounted drills may be installed if needed.

Cost Savings

Boeing Airplane Co. has devoted a great deal of study to the savings and efficiencies that are possible with numerical control equipment. Both its Seattle and its Wichita plants produce numerically controlled parts. At Wichita, careful records were kept of duplicate runs in which a part was made on operator controlled equipment using standard methods and on numerically controlled machines.

In one operation studied, the cost of making a part using a tracer-controlled milling machine was over $18,000. This included costs for building a full sized model which provided the pattern for the part. Using a numerically controlled mill, the same part cost only $2000. In making the first part by each method, the tracer controlled mill required 1400 hours while the automatically controlled machine took only 700 hours. On subsequent runs, the tracer mill dropped its time to 750 manhours while the numerically controlled mill turned out parts in 250 hours.

Circle 685 on Page 19

For Literature on Cylinders, Circle No. 686→
For Literature on Fittings & Hose, Circle No. 687→

PARKER-HANNIFIN FLUID SYSTEM COMPONENTS

Hannifin high-pressure hydraulic cylinders feature a drip-free rod gland with "LIPSEAL"® and "WIPERSEAL." This feature, plus straight-thread, O-ring-sealed ports, insures leak-proof cylinder installations.

Parker "Krimp-lok" permanent-end hose assemblies and "Hoze-lok"® reusable fittings can be ordered with O-ring-sealed straight threads to insure leak-proof hydraulic connections to 5,000 psi.

from **PARKER-HANNIFIN...**

straight-thread ports and fittings for leak-proof hydraulic systems

Both Parker "Triple-lok"® flare-type and "Ferulok"® flareless fittings include straight-thread shapes in steel and stainless steel for leak-free tube connections. Write for our handy "Fittings Finders" for quick selection of Parker tube fittings, hoses and hose fittings.

Parker straight-thread hydraulic fittings, mated with S.A.E. bosses (offered at *no extra charge* on Hannifin cylinders), guarantee leak-proof cylinder port connections.* This use-proved sealing method is J.I.C. recommended.

To insure leak-proof performance throughout your hydraulic systems, Parker offers both "Triple-lok" flare-type and "Ferulok" flareless fittings for leak-proof tube connections. Where you need high pressure, permanent-end hydraulic hose assemblies, Parker supplies "Krimp-lok." And for fast, leak-proof field service or replacement, Parker "Hoze-lok" fittings require no skiving of the hose, need a minimum of tools for assembly.

Your Parker-Hannifin man is qualified to help you with installation problems. He'll also help you plan your hydraulic layouts.

**Both Parker fittings and Hannifin cylinders are still available with "dry-seal" pipe threads.*

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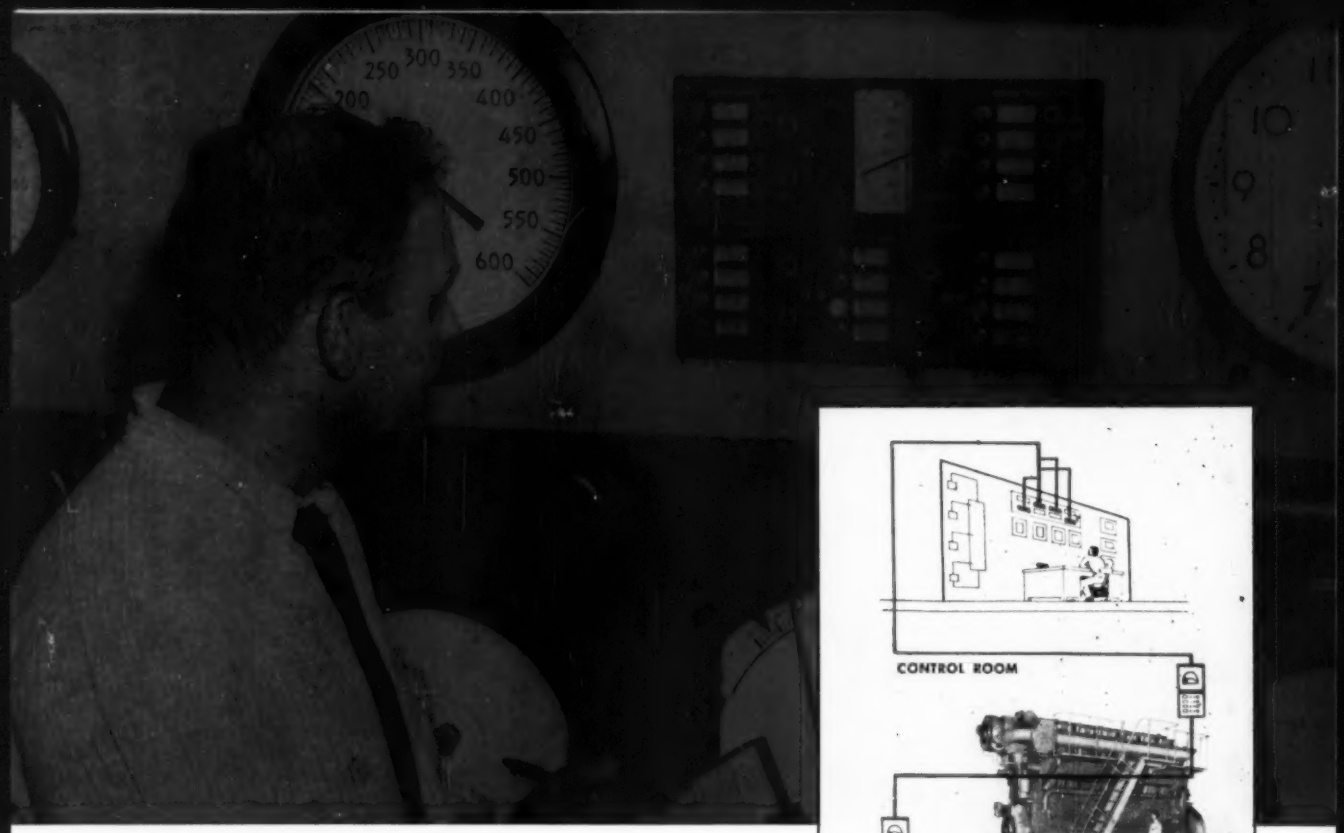

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EDISON

omniguard systems protect equipment, decrease downtime in generating plants

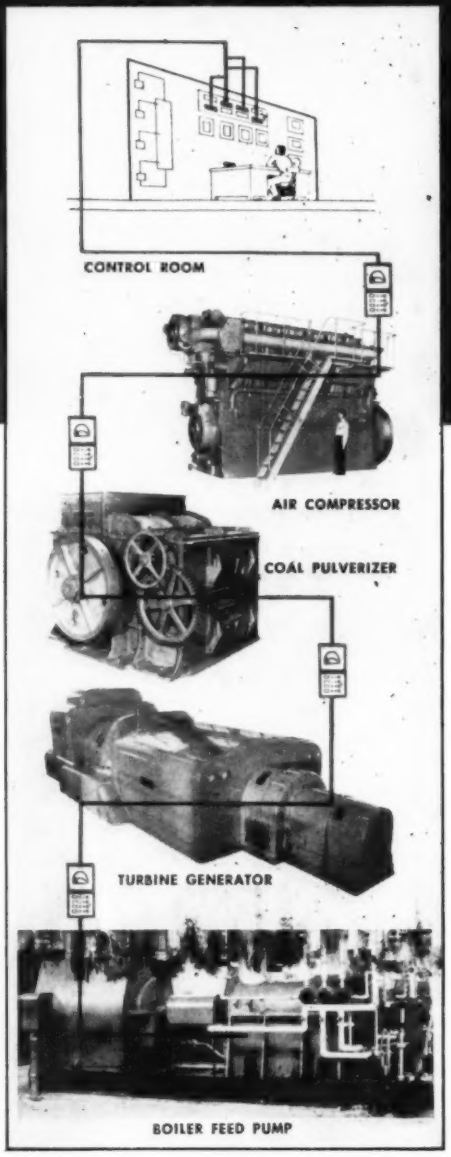
The Edison Omniguard system keeps constant watch on critical temperatures throughout electric generating plants. Omniguard monitors such vital temperatures as those of bearings on the main turbine generator, fluid drives, coal pulverizers, main feed pumps and other vital auxiliaries.

When overheating occurs the alarm sounds *before* damage occurs and corrective action may be taken immediately.

By guarding against overheating the equipment runs at optimum efficiency, lasts longer and requires less maintenance.

This modern Edison system is a simple, reliable means of keeping equipment operating at full efficiency and protecting against emergency shutdown.

For additional information on Edison Model 310 Omniguard temperature monitor and the wide variety of detectors available for use on all types of auxiliaries, pressure vessels, tanks and pipe lines, write for publication 3036C.



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INSTRUMENT DIVISION
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McGRAW EDISON

Circle 764 on Page 19

Inevitable

"ASSUMING our free competitive system remains with us, there are many factors which make automation at an increasing rate inevitable. The consumers, the workers, and their families will profit from automation in a tremendous way, and some companies will forge ahead as a result of automation. Others, not realizing its potentiality and inevitability, will fall by the wayside."

In retrospect, this statement in our January 1959 issue takes on new significance. Made by C. H. Thayer, vice president in charge of manufacturing, Sun Oil Co., it appears somewhat prophetic as we take a careful look at the forces in action today.

Study of these forces shows two major areas of pressure driving all industry to seek the opportunities possible only through automation techniques. Included in the first area are forces of broad national and international character;

1. International technological competition.
2. Demand for higher living standards.
3. Pressure of population increase.
4. Expanding horizons of scientific knowledge.

while in the second are the active everyday business forces;

1. Rising capital and overhead costs.
2. Need for higher product quality and uniformity.
3. Increased manufacturing competition.
4. Added business volume and complexity.

Under the relentless impact of this powerful array of forces, automation is indeed inevitable. Just to maintain our past rate of progress, it is estimated that a productivity gain of 35 per cent will be necessary by 1966 and 66 per cent by 1976.

In the fast-moving era of the 60's there can be no turning back. Only through expanded use of automation will the U. S. maintain its world leadership and standard of living.

EDITOR

ELECTROHYDRAULIC SERVO SYSTEMS FOR MACHINE CONTROL

By ROBERT L. FILLMORE
Manager, Machine Controls Products Dept.
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

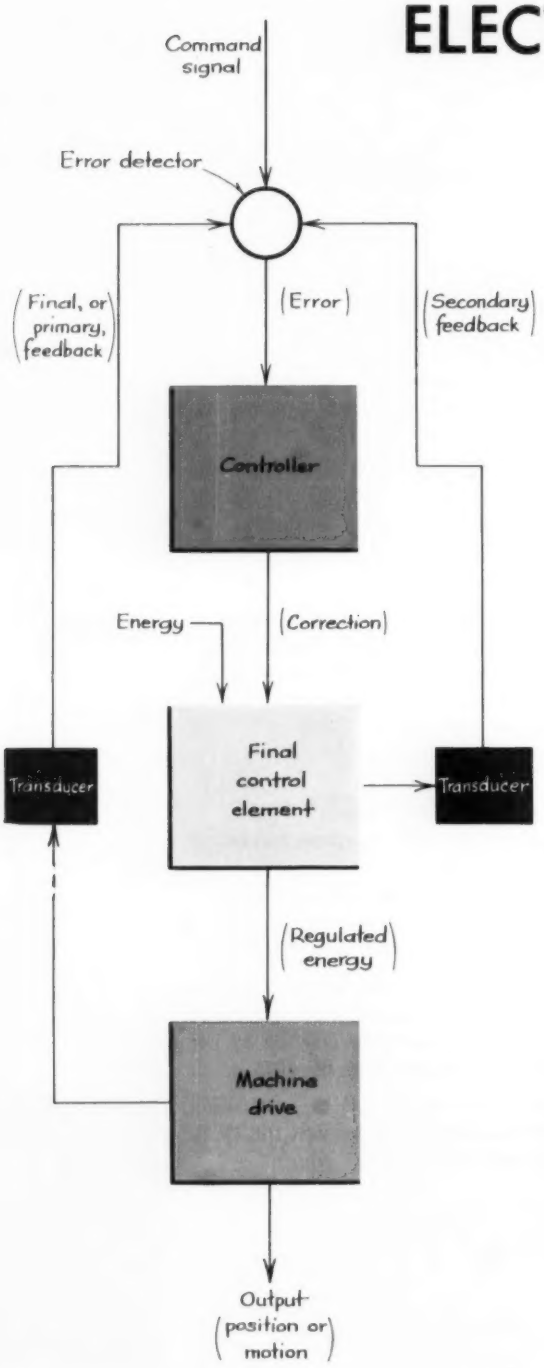


Fig. 1—Block diagram illustrates basic elements of an electrohydraulic servo control system. Function of system is to provide output motions or positions of machine elements that accurately reflect input signal commands.

FAVORABLE results obtained with electrohydraulic servo control systems for machine tool and other industrial applications can be traced primarily to the combination of desirable characteristics inherent in available electrical and hydraulic control elements. In effect, electrohydraulic control systems combine the speed, sensitivity, and adaptability of electronics with the force-exerting capabilities and flexibility of application of hydraulics. The state-of-art level in both technologies —electronics and hydraulics—is such that standard components are directly usable in most industrial servo control systems.

A review of the requirements of a basic electrohydraulic servo control system, and the types, advantages, and limitations of the components that may be used, will assist an understanding of this control means. An application example will then be given describing a machine that employs several separate electrohydraulic servos to control spindle speed, simple positioning, and two-axis tracer positioning. Finally, a variety of other industrial applications for electrohydraulic servos will be outlined, and accuracy and power handling capabilities discussed.

Basic Servo Control System

A block diagram of a typical electrohydraulic servo control system for machine control is shown in *Fig.* 1. Command signals proportional to desired positions or motions are introduced to the system in

Distinguishing characteristics of electrohydraulic servo control systems—versatility and flexibility—qualify them for a variety of industrial applications involving close control of motions or positions. The author discusses basic principles, typical applications, accuracy, and power handling capabilities of several versions of this type of control means. Particular emphasis is placed on the advantages of variable displacement piston pumps and motors as the controlled elements of complete systems.

the form of voltages, pressures, etc. These reference inputs may be manually set, or they may vary continuously and automatically.

Final, or primary, feedback signals are generated by a transducer whose output reflects actual (as opposed to desired) positions or motions of the machine member being controlled. When there is wide disparity between the desired and actual positions or motions, a comparison of the command and final feedback signals results in relatively large error signals. Conversely, as the desired and actual positions or motions become equal, the error signal drops to zero, indicating that the desired effect has been accomplished.

Intermediate, or secondary, feedback signals may also be used in a servo system. These signals are proportional to the actual positions or motions of the final control element that regulates the energy input to the machine. The function of these feedback signals is to verify the response of the final control element to control signals. Secondary feedback of this type anticipates the need for output corrections by indicating rates of change of energy inputs (velocity or acceleration). The effect is to counteract overcorrection tendencies and stabilize the control system.

As suggested by the block diagram, the function of the controller is to translate the error signals into correction signals in a form acceptable by the final control element. The final control element, in turn, translates the correction signals into regulated, corrective changes of energy input to the machine.

▶ Servo Control Components

An electrohydraulic servo control system for machine control includes three general types of components: 1. Transducers for generating command and feedback signals. 2. Electrical or electronic equipment for interpreting the signals and translating them into correction signals for application to a final control element. 3. A final control element (usually a servo valve) capable of translating the correction signals into regulation of the hydraulic power input to the machine drive.

In the narrowest sense, these three types of components comprise all of the actual control system. Yet, the characteristic response of machine drives to control signals, and to load variations, plays such an important part in the over-all results that the hydraulic drive components—including pumps, motors, and cylinders—are usually considered as part of the control system. Indeed, when variable displacement pumps and motors are used, the final control element, in the conventional sense, is the stroke-adjustment mechanism of the pump or motor.

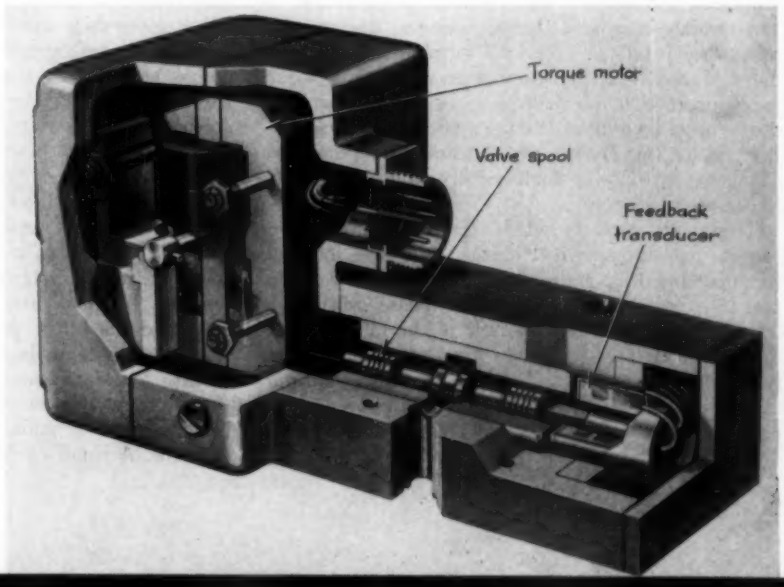


Fig. 2—Single-stage electrohydraulic servo valve uses an electrically operated torque motor to position valve spool with respect to orifices in a sleeve. Output flow is approximately proportional to input current at constant load pressure. Integral transducer at right end of valve provides electrical signals indicating spool position.

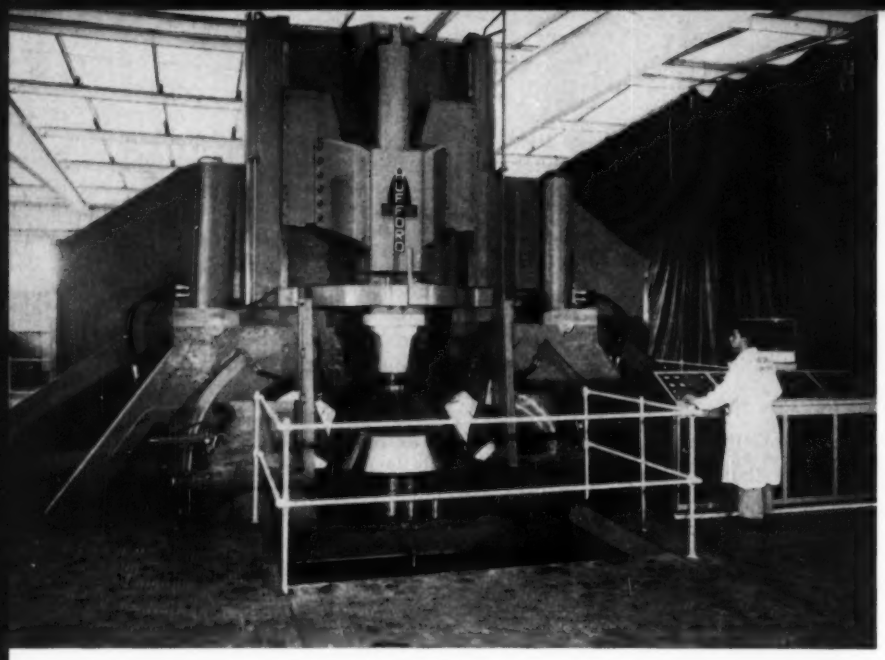


Fig. 3—Roll forming machine accepts 60-inch diameter metal blanks up to 1 inch thick and forms them into surface-of-revolution shapes over a mandrel. Spindle speed, forming roll attack angle, and roll tracing are controlled automatically by multiple electrohydraulic servo systems.

Transducers. In general, transducers used in electrohydraulic servo control systems must have high sensitivity in the sense of low threshold or minimum dead zones. That is, extremely small changes in deflection (or in deflecting forces) should produce usable signal changes. The signals generated should also have virtually infinite resolution, which is the first requisite for stepless control response of the systems.

Potentiometers are used as transducers in many electrohydraulic servo control systems. In general, however, command and feedback signal generators of the electromagnetic type—tachometers, synchros, resolvers, and variable reluctance devices—are preferred. With no contacts to wear or corrode, and with negligible frictional wear of moving parts, electromagnetic transducers are reliable and have long life. Because of their mechanical simplicity, these devices are a relatively inexpensive means of providing accurate control sensing.

In electromagnetic transducers, the variable reluctance principle of the variable transformer is most widely employed. In one version, the variable reluctance principle takes the form of a single-primary, dual-secondary transformer. A portion of the magnetic core is movable so as to permit changing the relative lengths of the magnetic flux paths. Motion of the magnetic core is usually produced by displacing a follower shaft axially from its neutral, or centered, position.

The two secondary windings of the transformer are of opposite polarity. Hence, with the follower centered and flux paths equal, the induced voltages are 180 electrical degrees out of phase with each other, and cancel. Displacement of the follower and movable core element from the centered position, however, results in a differential voltage output that is proportional in magnitude to the amount of displacement and corresponds in phase angle to the direction of displacement.

Another basic type of variable displacement transformer commonly used consists, in effect, of two such two-pole devices combined into one, with the four poles spaced at 90-degree intervals around the movable core element in the center. The windings are so connected that the voltage induced in each secondary coil is 90 degrees out of phase with the voltages induced in the adjacent secondaries, leading in the one coil and lagging in the other. Thus, variations in flux-path lengths produce voltages varying, as before, in magnitude, but varying also in phase angle over the full range of 360 degrees.

Variation of flux-path lengths may be produced by lateral displacement of an armature carried on the stylus shaft of a 360-degree tracer transducer, or by rotary displacement of a magnetically eccentric core about its axis. The latter is used especially for sensing the angular positions of rotary members. Frequently, manual command (set-point) adjustment means are of this type.

To be usable, transducers must be designed for application to machines in industrial environments. Therefore, their mechanical construction should be as simple and rugged as possible. Usually, they must be oil-tight and dust resistant. Friction and lost motion may be minimized by the use of flexure pivots and minimum loading on bearing surfaces.

Electronic Equipment. Available electronic amplifiers and other components that combine, compare, manipulate, and interpret control input signals offer highly desirable features of speed and flexibility. The negligible lag in transmission of electric signals over a distance is significant in remote-control applications, but may also be important in applications to large machines. Most striking, however, is the flexibility obtainable with present electronic equipment. Standard control amplifiers and standard transducers can be combined, with little if any modification, to make up a wide variety of control systems. A small or large number of command and

feedback signals can be readily combined and utilized to provide various control sequences and over-all performance to meet widely different application requirements. This flexibility in system design and application includes, and to a large extent depends upon, the convenience with which various adjustment functions can be provided. Thus, the operating characteristics of a given control system can be readily matched to the requirements.

The advent of transistors has had much to do with making electronic equipment practical for use in industrial environments. With some attention to mechanical construction, electronic equipment incorporating transistors and other solid-state components can be compact, rugged, and reliable.

Servo Valves. A major factor in the trend toward electrohydraulic controls has been the successful development of the servo valve. This component is the transfer link between the electronic control and the hydraulic power. The servo valve performs its function by converting electrical input signals into high-power hydraulic flow and pressure. This output, in turn, is used directly to drive various types of hydraulic actuators or to control variable displacement pumps or motors.

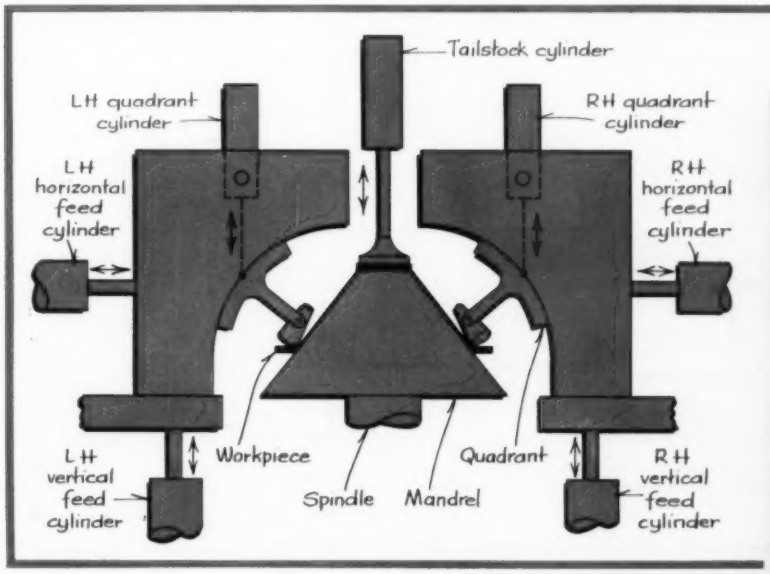
A typical electrohydraulic servo valve is illustrated in *Fig.* 2. This is a single stage unit, with three or four-way porting, which utilizes a permanent-magnet, differential-current torque motor to position a sliding spool relative to rectangular orifices in the sleeve. The valve can be thought of as an infinitely variable, high impedance hydraulic device. Output flow is approximately proportional to input current at constant load pressure. Variations in load characteristics are reflected back to the servo valve but, because of its high impedance, the output performance of the valve is not greatly affected except when operation is near load saturation.

Servo valves provide the rapid speed of response and high accuracy essential to servo control systems. For example, the valve illustrated has a time constant of the order of 5 milliseconds. This is the time for the spool to move a distance equal to 63.2 per cent of its full travel (0.015 inch) from the center position. Of course, only a small portion of this travel is required to effect a significant change in hydraulic pressure or flow output.

Other characteristics of servo valves that contribute to efficient system performance are high pressure gain, near-zero dead band, minimum threshold, and low hysteresis.

A feature of the servo valve illustrated in *Fig.* 2 is a built-in feedback transducer. The movable core of the variable-reluctance type transducer is integral with the valve spool. Thus, the output voltage of the transducer is proportional to the spool displacement. This voltage, when fed back to the input side of the valve-control amplifier, improves the frequency response of the amplifier-valve control loop. It also permits a high static gain adjustment that substantially reduces the effects of any static friction or hysteresis present.

Hydraulic Drives. Power drives utilizing hydraulic pumps, motors, and cylinders display several characteristics of interest from the control standpoint. The inertia of a hydraulic drive (as distinguished from that of the driven machine mass) is usually small in proportion to the force developed. Consequently, hydraulic drives in general have fast re-



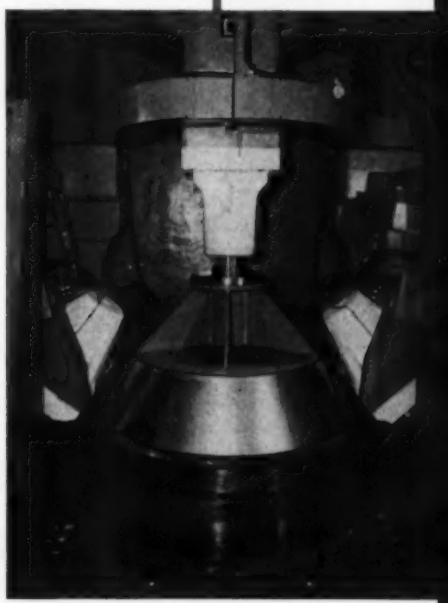


Fig. 4—Sketch illustrates hydraulic components used to feed forming rolls in two axes and to adjust tool angles with respect to work. Close-up shows relationship of workheads to spindle. Vertical member is tailstock that clamps workpieces to mandrel on spindle.

sponse to control inputs. They also offer wide speed range, particularly in applications requiring zero or near-zero speed. In addition, full force is available at zero speed and zero power output. In proportion to their power ratings, hydraulic power drives are relatively compact and inexpensive.

Variable displacement piston pumps and motors have several advantages from the standpoint of servo control, particularly at high power and force levels. For example, their characteristically low slip is important with respect to linearity of position under varying tool loads. The reduction or elimination of gearing possible with these components minimizes backlash, which may be critical when reversals of direction are involved.

Usually, minimum-volume systems are required to fully realize the benefits of the positive displacement characteristic. For, in large-volume systems, fluid compressibility may introduce load-variation errors that affect system performance. Properly applied, however, variable displacement piston pumps and motors respond rapidly to changes in load, avoiding the lags involved when the control system must detect errors due to load changes and correct for them.

Other features attractive to the control engineer are the relatively fast control response and the high power gain available. A typical 100 horsepower pump, for example, can be stroked from full forward to full reverse delivery in less than a second. Although this is slow in comparison with the response of a servo valve, it is almost always much faster than a comparable load can respond. In terms of hydraulic power input to the stroking or adjusting mechanism, such a pump exhibits a power amplification factor of the order of 500, with negligible reflection of output load variations to the servo valve controlling the pump.

▶ Roll Forming Application

The machine illustrated in *Fig.* 3 furnishes an interesting example of the use of multiple electrohydraulic servo control systems in a large machine tool. Built by Hufford Div., Siegler Corp., the unit is in use at the Utah facility of Marquardt Aircraft Co. Called "Spin Forge," the machine forms surface-of-revolution parts from flat or semiformed metal blanks. Typical finished shapes that may be produced include cones, cylinders, venturis, and parabolas of revolution.

Physical aspects of the forming section of the machine, and some of the servo controlled hydraulic components used, are shown in *Fig.* 4. In operation, one or two hardened rolls may be brought against a workpiece clamped by a vertical tailstock cylinder to a rotating mandrel. As the rolls are moved on a predetermined path, the metal blank is progressively extruded over the mandrel. Unlike spinning, the process produces parts that are thinner than the original metal. In addition, the parts may be tapered in cross section.

Size of the machine is such that 60-inch diameter blanks, up to 1-inch thick, may be accommodated.

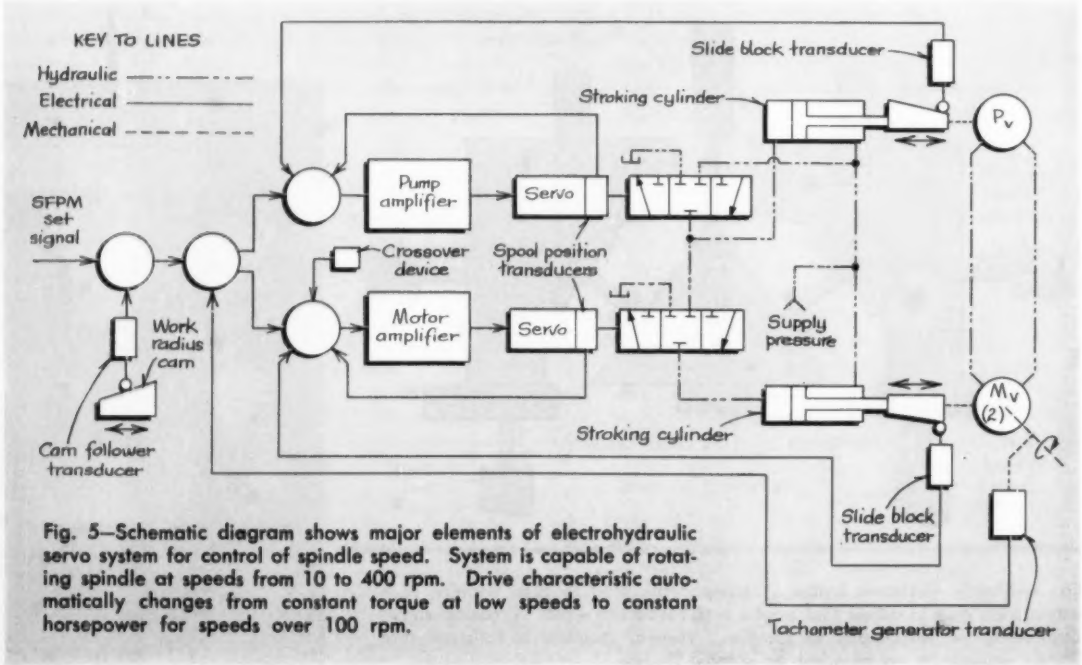


Fig. 5—Schematic diagram shows major elements of electrohydraulic servo system for control of spindle speed. System is capable of rotating spindle at speeds from 10 to 400 rpm. Drive characteristic automatically changes from constant torque at low speeds to constant horsepower for speeds over 100 rpm.

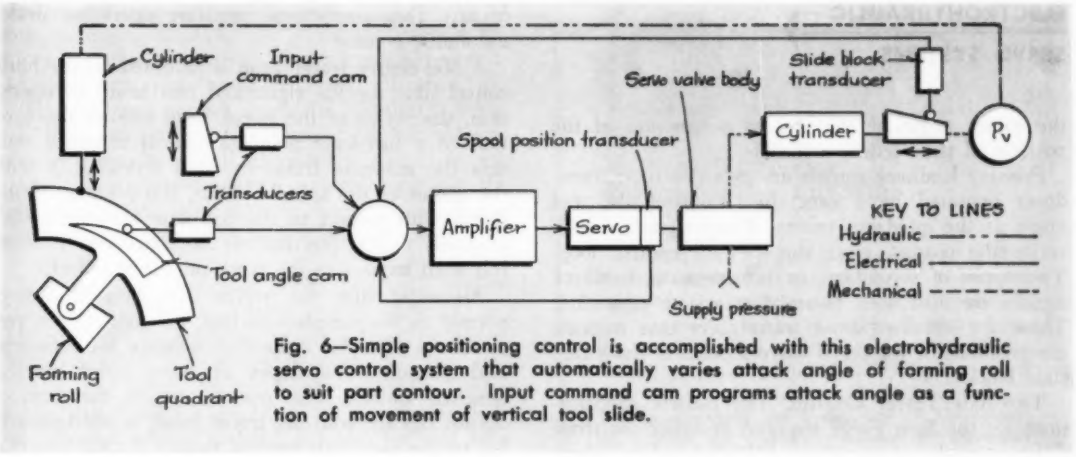


Fig. 6—Simple positioning control is accomplished with this electrohydraulic servo control system that automatically varies attack angle of forming roll to suit part contour. Input command cam programs attack angle as a function of movement of vertical tool slide.

Finished parts may be 60 inches in diameter and have a length of 60 inches.

Electrohydraulic servo systems control three distinct machine functions: Spindle speed, forming roll attack angle, and roll tracing. The latter function involves continuous tracer control of both horizontal and vertical positioning of the forming rolls with respect to the mandrel. Each of these systems will be discussed separately.

Spindle Speed. Requirements of the hydraulic spindle drive call for continuously variable speed from 10 to 400 rpm. Up to 100 rpm the drive characteristic is essentially constant-torque; above 100 rpm it is nominally constant-horsepower.

In operation of the spindle speed control system, *Fig.* 5, an electrical signal is generated by an electromagnetic cam-follower transducer. This signal, which is proportional to the inverse of the distance from the center of the spindle to the rolls, is combined with a manually set surface speed command signal. The resultant is further combined with a motor speed feedback signal from a tachometer generator, and the error signal is fed to two amplifiers.

Output of one of the amplifiers is fed to a servo valve controlling the stroking cylinder of a variable displacement pump. Output of the second amplifier goes to a servo valve that controls the stroking of a pair of variable volume hydraulic motors. Primary power for the pump is supplied by a 200 horsepower electric motor; the hydraulic motors are connected to the machine spindle through a 3.4 to 1 ratio gear reducer.

In the constant-torque mode of operation at spindle speeds from 10 to 100 rpm, the hydraulic motors are held on full stroke and the pump stroke is adjusted to determine spindle speed. Maximum speed of 100 rpm in this mode is attained with the pump fully stroked for maximum displacement. From 100 to 400 rpm, where constant-horsepower operation is desired, the pump is held on full stroke and the motors are stroked down to increase speed. At their maximum speed of 400 rpm, the motors are stroked to about one-fourth of their maximum displacements.

Full stroking of the motors is maintained in the low speed range by a crossover device connected to the motor amplifier input. In effect, a fixed signal from the crossover device overcomes, and cancels, speed input commands to motor control circuits in the range from 10 to 100 rpm. This results in the motors being held at full stroke. As speed commands increase above 100 rpm, however, an increasing output is available from the motor amplifier to the motor servo valve. This restores stroke control for constant-horsepower action in the speed range from 100 to 400 rpm.

An interesting feature of the spindle speed control circuit is the provision for foolproof sequencing of the pump and motor slide blocks so that the pump must be on full stroke before de-stroking of the motors can begin. The pump slide block is positioned, or stroked, by a 2 to 1 area cylinder with pressure to the blind end varied between zero and full supply pressure by a three-way pump servo valve. Oil supply to the motor servo valve is also taken from the cylinder port of the pump servo valve. Because of the 2 to 1 area relationship between the blind and rod ends of the motor stroking cylinder, this cylinder will not advance until a pressure exceeding half the supply pressure is received from the motor servo valve. But, because of the pressure dividing action of the servo valves, this is impossible until the pump stroking cylinder bottoms on full stroke and blind end pressure builds up to equal supply pressure. When this occurs, movement of the motor stroking cylinder can begin.

Tool Angle Setting. Separate positioning systems are used for pivoting each forming roll. The system for one roll is diagrammed in *Fig.* 6. In operation, a roll pivoting quadrant is positioned by a hydraulic cylinder powered by an Oilgear Co. variable displacement pump. The pump-stroking cylinder is controlled (as in the spindle drive system) by an electrohydraulic servo valve. Input commands to the system are generated by a transducer operated by an input command cam. This cam programs

the attack angle of the tool as a function of the position of the vertical tool slide.

Primary feedback signals are provided by a transducer operated by a cam that indicates the tool angle as the quadrant moves. These signals, which verify the output, close the over-all control loop. Two types of secondary, or intermediate, feedback signals are also used to stabilize system operation. These are obtained from transducers that indicate the positions of the servo valve spool and the pump slide block.

Two-Axis Tracer Control. The control specifications for the Spin Forge required provision for three different modes of operation: 1. Righthand roll alone controlled by a template. 2. Both rolls controlled from a single template, with the lefthand roll slaved to the righthand tracer controls. 3. Both rolls operating independently from two separate templates, but with tracing speed of the lefthand system synchronized with the righthand vertical slide rate.

The requirements were met by two complete electrohydraulic two-axis tracer control systems—one for each set of vertical and horizontal roll-feed slides—with supplementary elements for the necessary synchronizing control. With these systems, each of the four slides is rated to deliver a maximum thrust of 225,000 pounds, at feed rates up to 40 ipm, in either direction. With 3000 psi system pressures provided by Oilgear Co. variable displacement pumps, peak hydraulic power per slide is approximately 22½ horsepower. Part-to-template accuracies are ±0.003 inch at tracing speeds up to 10 ipm and ±0.005 inch at maximum tracing speed.

A condensed diagram of the righthand tracer control system is shown in *Fig.* 7. Sequence of operation of this system reflects the basic requirements of any two-dimensional profiling operation under automatic control.

A 360-degree tracer head is mounted on the horizontal slide for the righthand tool head. In operation, the stylus of the tracer head follows the contour of a full-scale template that is mounted outside the machine frame in fixed relationship with the center of the spindle. Thus, the position of the stylus with respect to the template accurately corresponds to the position of the righthand forming roll with respect to the work on the mandrel.

Assuming that the stylus deflection is always normal to the template surface, the magnitudes and directions of stylus deflection indicate the locations and instantaneous slopes at every point on the template surface. This information, in the form of output signals from the tracer head, is continuously fed to the electronic control system during forming. Also fed into the control system is a signal obtained by comparing the output of a tachometer (proportional to spindle speed) and a manually set signal representing a surface feed rate command.

Together, these input signals provide the basic command information describing the path the stylus is to follow and the speed at which it is to move at any instant. This command information is then resolved into horizontal and vertical components and fed to separate servo valves. The valves, in turn, regulate the positions of pump-stroking cylinders so that the pumps will properly actuate the horizontal and vertical cylinders controlling positioning of the tool head.

Stabilizing, or secondary, feedback signals are obtained from transducers in the servo valves and associated with the pump slide blocks. The tracer head closes the servo loop by providing primary feedback. That is, the deflection signal that provides the basic command information for positioning the tool also provides a measure of the actual position and motion of the tool.

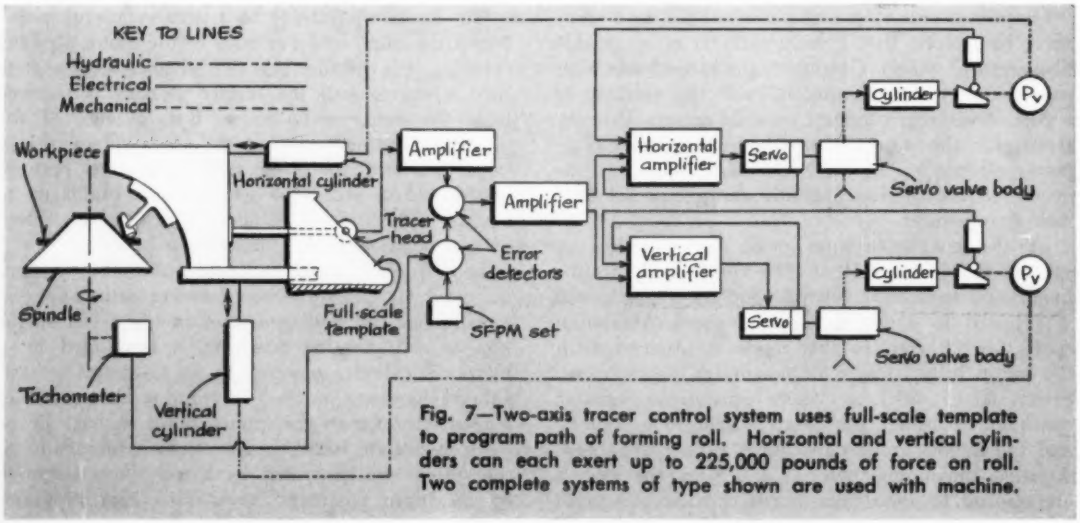


Fig. 7—Two-axis tracer control system uses full-scale template to program path of forming roll. Horizontal and vertical cylinders can each exert up to 225,000 pounds of force on roll. Two complete systems of type shown are used with machine.

When both left and righthand rolls are controlled from a single template, the command signals required to maintain lefthand slide movements in synchronism with righthand feeds are furnished by: 1. The feedback signals from the righthand pump slide block transducers. 2. Signals from vertical and horizontal synchronizing transducers. The latter are single-axis transducers that are mounted on the righthand slides, with their followers linked to the lefthand slides so as to detect any differences in position.

In operation with two templates, each system utilizes its own tracer command and feedback signals, and also the speed signal from the tachometer. The only other connection between the two systems during actual tracing is the vertical synchronizing signal, which modifies the speed signal to the lefthand system to keep the two forming rolls moving in synchronism.

Other Applications

Electrohydraulic servo control can be applied advantageously to a variety of machines and machine functions. For example, spindle speeds of machines such as lathes and boring machines can be controlled over a wide range to accommodate changes of work radii. Feed screw speeds may also be controlled as a function of spindle speed. On one turret lathe, feed screw speed can be controlled in proportion to spindle speed over a range from 1.5 to 1800 rpm, with a maximum error of ½ revolution.

Speed control with special reference to acceleration and deceleration rates offers interesting possibilities for servo control. For example, a program cam and single-axis tracer head can be used to provide smooth deceleration of a rapidly moving slide (such as a sawmill carriage) as it approaches its limit of travel.

For operations requiring relatively low power levels, as in the control of tool feeds in typical metal cutting operations, direct servo valve control of cylinders or constant displacement motors generally takes precedence over control by means of variable displacement pumps.

Simple positioning control, as exemplified by the roll-pivoting system for the machine previously described in detail, has obvious applications to swarfing operations. It may be applied to linear as well as angular motions. In fact, if the program cam is replaced with a full-scale template, the system becomes a single-axis tracer control system. With constant feed in a second axis, such a system can be used on a lathe to reproduce contours with moderate rates of curvature or taper.

With constant longitudinal feed of a workpiece, and the cutting axis at right angles, machining of steep tapers or shoulders would require cross feed rates approaching infinity. Systems are available, however, that can automatically reduce the longitudinal feed rate as the primary controlled feed rate increases. A small milling machine equipped with this type of contouring control has a specified accuracy of ±0.001 inch at tracing speeds of 10 to 20 ipm.

THE AUTHOR

ROBERT L. FILLMORE has served in the Machine Controls Products Dept. of Minneapolis-Honeywell Regulator Co. since 1955, the last two years as manager. Prior to joining the company, Fillmore was engaged in consulting work with Minneapolis-Honeywell and other manufacturers in Minneapolis.

A graduate of the University of Minnesota, he earned his master's degree in electrical engineering in 1949. From 1947 to 1955 he served on the faculty of the University in the Dept. of Electrical Engineering, specializing in electrical machinery and control.

The department which Fillmore heads up includes among its responsibilities the development and application of electrohydraulic systems and components including tracer controls, speed controls, and linear position transducers.

Two-axis, or 360-degree, tracer systems are applicable to a variety of machines such as lathes, shapers, planers, and milling machines. Indicative of performance obtainable is the reproduction, on a small milling machine, of a 4-inch circular template within ±0.005 inch at a tracing speed of 10 ipm. In general, two-axis tracer control is applicable wherever machine forces acting in two axes in a plane must be continuously co-ordinated to produce an accurately controlled motion or position.

Two or more basic modes of control are often required. A large contour milling machine, for example, might require simultaneous control of vertical, longitudinal, and cross feeds; and of tool head tilting in two planes. In such combinations, control in the third major axis may sometimes be effected by limit-switch actuation of an indexing feed that provides motion in small increments. In other cases, however, proper machine function may require servo control of all axes from program cams or templates.

Accuracy

Accuracy of a servo controlled machine is primarily a function of the sensitivity and repeatability of the control sensors and the over-all gain of the control system and power drives. But anything contributing to lags or false signals—machine resilience, friction, backlash, slip, or inertia—limits the amount of gain that can be used without overcorrection or instability. In two-dimensional tracing, for example, machine vibration may simulate non-

existent variations in template contour. Even surface imperfections in the template may be reproduced, and possibly amplified, since the stylus is capable of following extremely small changes in contour. Friction between stylus and template can change the angle of deflection of the stylus and thus distort the measurement of template position and slope.

Assuming, however, that such factors have been carefully considered in the design of the machine, some approximate figures may be cited as representative of accuracies attainable. These must, of course, be taken as orders of magnitude rather than definite specifications, and may vary widely from machine to machine.

Accuracy of speed control will depend on the inertia of the moving machine masses, the speed range, the required acceleration rates, and the elaborateness of the control system. Accuracy of 3 to 5 per cent is commonplace. Under favorable conditions, speed can be controlled over a range of 1000 to 1 with an accuracy of a fraction of 1 per cent throughout the speed range.

Taking two-dimensional tracer control as representative of the more complex control problems, a few orders of magnitude may be cited for various conditions of application. The main factors that must be considered in estimating probable accuracy are the required tracing speeds, the rates of change of template slopes, and the masses of moving machine elements relative to the forces available to accelerate them.

With small tracer machines such as lathes and milling machines, template-to-part accuracies of 0.001 to 0.003 inch are attainable on straight cuts or gradual curves at tracing speeds up to 40 ipm. Errors on small-radius turns (½ inch or less) may be as small as ±0.001 inch at low tracing speeds, but must be expected to increase considerably at speeds of 20 to 40 ipm. The magnitude of these errors at higher speeds will vary, with machine masses, from about 0.003 to 0.005 inch on small machines. For high speed operation of large, heavy machines, the magnitudes of the these errors may range up to several times the values quoted as attainable for smaller machines.

Sharp turns offer the most critical accuracy problem, because the power drives cannot accelerate and decelerate the machine slides at the high rates required for negligible overshoot at high tracing speed. Tracer machining of sharp turns, therefore, requires reduction of tracing speed. This can be accomplished by resetting a control dial, or by means of an auxiliary speed control function programmed to reduce tracing speed as the stylus approaches or enters a corner or sharp curve.

Inside corners are generally more critical than outside corners, for two reasons. Errors on inside corners are into the work; and the nominal tool path always has zero radius. On an outside corner, however, the path of the tool center is often (as in side milling) a curve with radius of half the tool diameter.

Certain design techniques may sometimes be employed to improve tracing control accuracy. For example, some templates can be compensated for self-repeating errors, so that part-to-part accuracies considerably better than template-to-part accuracies can be achieved.

Power Capabilities

The maximum power handling capability of an electrohydraulic control system depends upon several factors. In the roll forming machine application, for example, tracer control of the machine slides at the 20 horsepower level presupposes relatively slow rates of change in template contour. This is necessary in order to provide the specified accuracies and tracing speeds. Also, such power levels usually imply large machine masses, which inherently limit the attainable accelerations.

Granting such limitations upon speed of correction, accuracy, etc., it is fair to say that the power capabilities of electrohydraulic control systems are limited only by the availability of hydraulic pumps, motors, and cylinders having the required ratings. Hydraulics technology is advancing at a rate promising early extension of present power limitations.

can we help?

It has been pointedly mentioned at various times that in engineering automated systems new as well as old techniques and devices may prove extremely useful. Practical results require the investigation of all available equipment that can contribute to the effective development of suitable automatic lines. Information on such equipment is presented in various departments of the magazine each month as useful data become available. To aid in obtaining detailed data for further evaluation a post card is included on page 19. Take advantage of this service. The Editors will be glad to help in this or any other way.

PRODUCING RIGID CONDUIT

FACILITIES at the Verona plant of Pittsburgh Standard Conduit Co. include several unique automatic setups that have enabled the company to increase its production capacity by more than 25 per cent. This plant converts raw steel pipe, ranging in size from ½ inch through 6 inches in diameter, into electrical conduit having a hot-dip galvanized, electrogalvanized, or black enamel finish. The plant also produces thin-wall electrical metallic tubing with galvanized exterior walls and lacquered interior surfaces in sizes from ½ inch through 2 inches.

As an inplant project of the firm's engineering and production departments, an automated hot-dip galvanizing unit was developed to accommodate conduit in the complete range of diameters produced. Depending on diameter, up to 18 sections of 10-foot lengths of conduit can be handled each minute.

Raw stock is received in approximately 20-foot lengths and automatically cut into two 10-foot sections. The cut lengths are fed by conveyor to a threading machine where both ends are threaded. Batches of threaded pipe are prepared for galvanizing by pickling and immersion in a preflux of zinc-ammonium chlorate. After the preflux dip, individual lengths are moved by a chain conveyor through the hot-dip galvanizing machine. After conduit emerges from the molten zinc tank, *Fig.* 1, it passes through a system of "wiping" stations that utilize the flow of superheated steam and air to keep the zinc evenly coated on the inside and outside walls of the conduit.

Subsequently, conduit is ejected into a quench tank, a special chromic acid treatment tank, and hot-rinse water tanks. Following an inspection operation, small diameter conduit is automatically bundled and moved to storage. Large conduit is not bundled.

The later stages in automatic processing take place on lines similar to that shown in *Fig.* 2, which illustrates equipment used in the manufacture of electrical metallic tubing. The exterior of the thin walled tubing is galvanized by an electrolytic process in lieu of the hot-dip process. Following the electrolytic process, the tubing is inspected, and aluminum lacquer is automatically sprayed on interior walls by the setup shown in *Fig.* 2. As the individual sections are conveyed away from the spraying stations, hot air jets wipe excess lacquer from the tubing. At the end of the line, the tubing is automatically marked and bundled for storage.

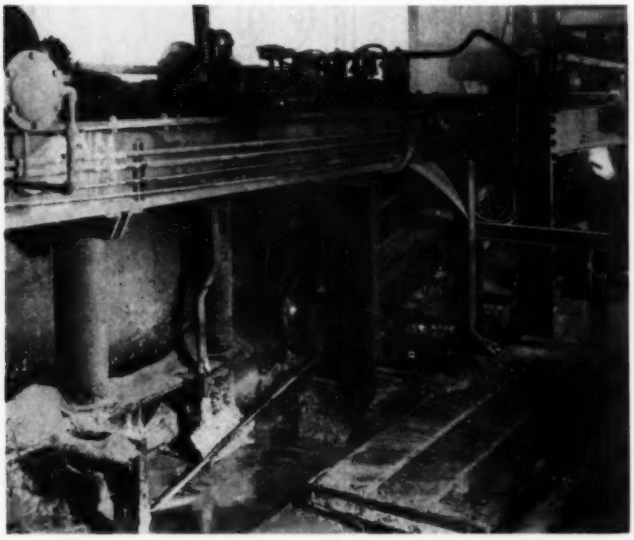


Fig. 1—Conduit is moved through a hot-dip galvanizing machine by a conveyor. At the output end of the machine (shown), conduit passes up and out of the zinc bath, being lifted by a magnetic roller that directs the lengths to a chain conveyor. The second conveyor connects several "wiping" stations at which a flow of superheated steam or air is directed against the conduit to keep the fluid zinc coating evenly spread.

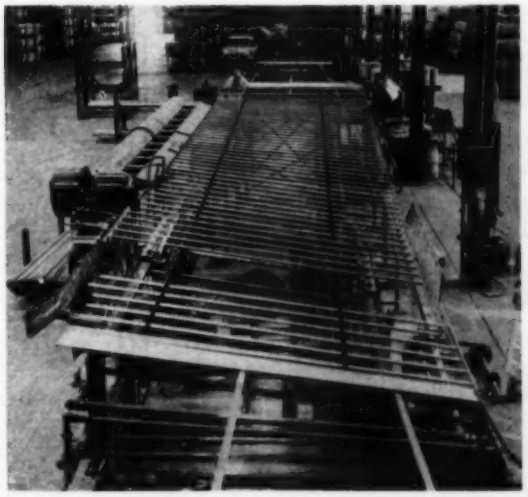
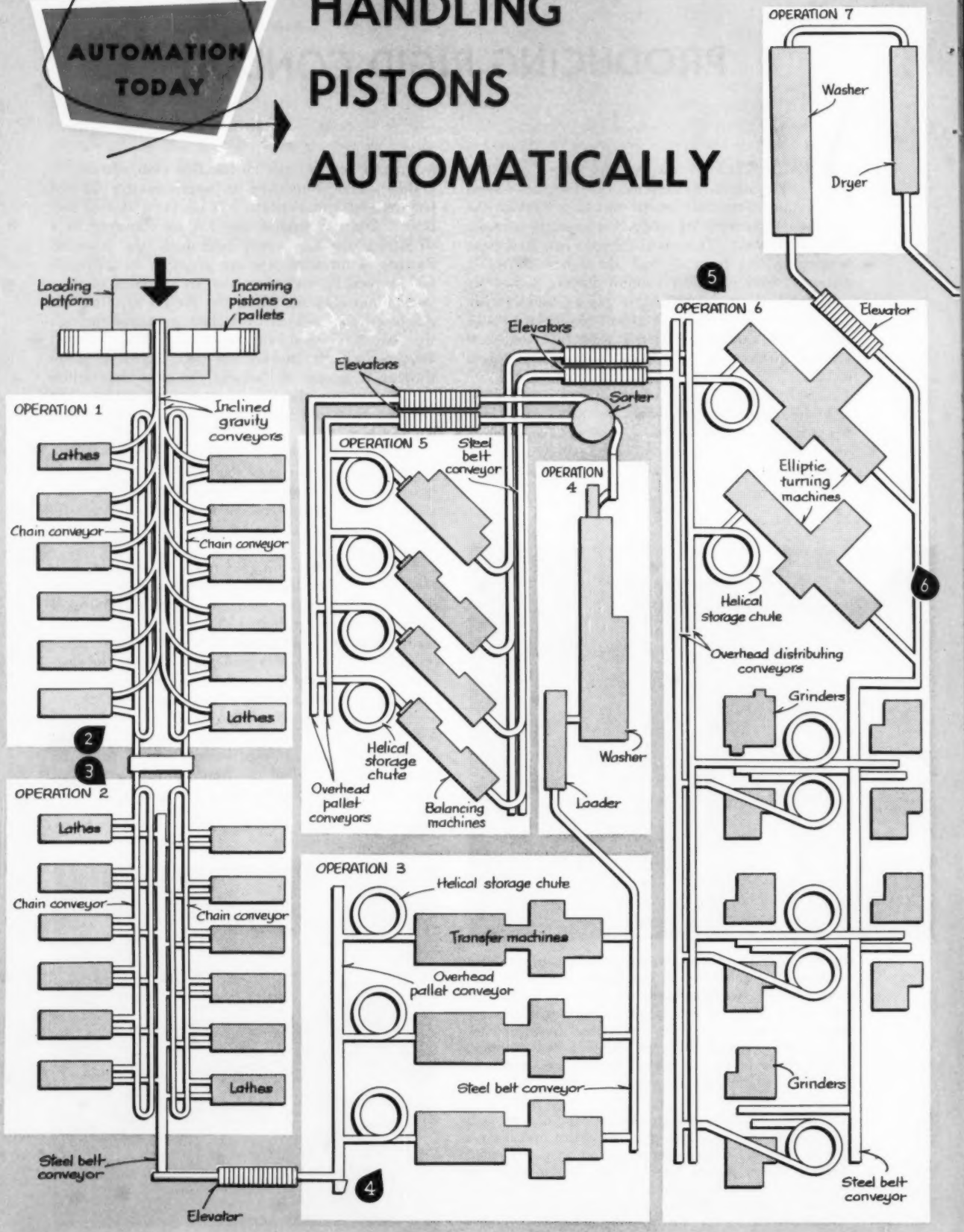
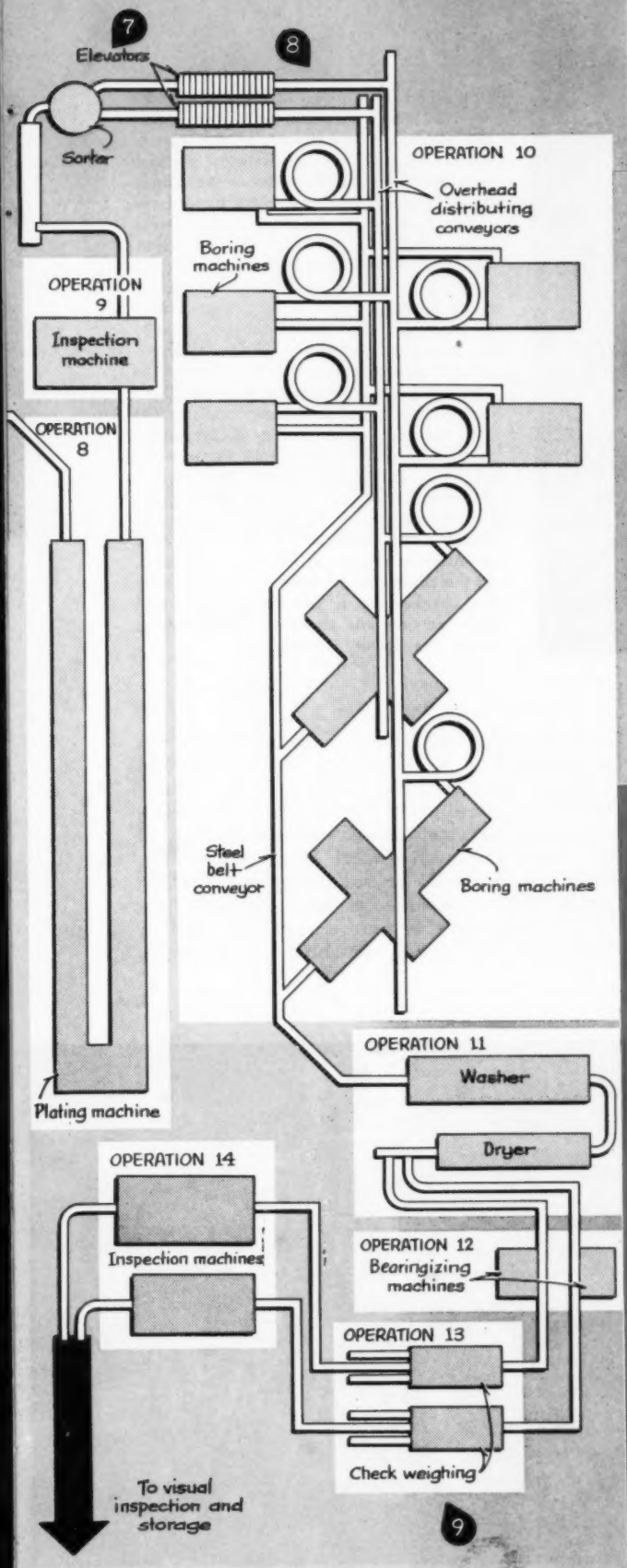


Fig. 2—Having been galvanized on exterior wall in an electrolytic process, thin-walled electrical metallic tubing is passed before a spray station where aluminum lacquer is sprayed on interior walls. During movement to end of the belt where it is marked and bundled, tubing is subject to blasts of hot air from jets in order to remove excess lacquer from the tubing.

AUTOMATION TODAY

HANDLING PISTONS AUTOMATICALLY





MACHINING of aluminum pistons is a highly developed process at the Lansing, Mich., plant of the Oldsmobile Div., General Motors Corp. Precision is essential in order to attain proper fit of pistons in cylinder bores which have been honed to close tolerances. For example, these fits are so critical that outside diameters of pistons are machined in a series of sizes which vary in steps of 0.00025 inch. Since a change in temperature of only 5F will alter piston outside diameter by about 0.00025 inch, final gaging for size classification is done only after the pistons have been normalized to a uniform temperature in an environment chamber.

In addition to close control of outside diameters,

1

Flow diagram shows the extensive automatic handling facilities that have been installed at an automotive engine production plant to transport two sizes of pistons through various machining, inspection, plating, and cleaning operations. At many places in the system, elevators are used to lift pistons from waist high operating levels to overhead conveyor systems which feed in-process helical storage chutes preceding the next production operation.

Sequence of Operations

Operation 1—Bore open end, face & chamfer bosses at open end, produce center in head end boss.

Operation 2—Turn outside diameter, finish face head end, turn ring grooves and chamfer.

Operation 3—Drill locating holes in open end bosses, rough bore pin hole, remove head end center boss.

Operation 4—Wash and dry.

Operation 5—Balance pistons and face skirt to length.

Operation 6—Turn or grind elliptic skirt.

Operation 7—Wash and dry.

Operation 8—Tin plate exterior surfaces.

Operation 9—Inspect.

Operation 10—Turn lock ring grooves and finish bore pin hole.

Operation 11—Wash and dry.

Operation 12—Bearingize pin hole.

Operation 13—Check piston weight.

Operation 14—Gage and inspect.

2

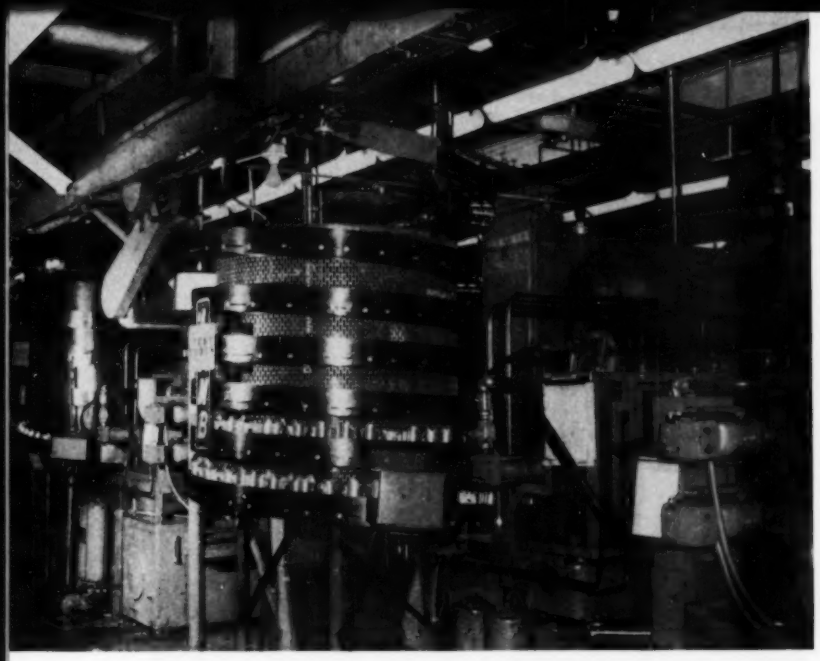
Unfinished pistons in two diameters are received from suppliers on pallets which are placed on a platform at the start of the production line. As received, the outside diameter of the pistons has been rough turned, and the ends have been rough faced. A small projecting center boss remains on the head of each piston. The pistons are unloaded from the pallets by hand; gaged for outside diameters, head thickness, and weight; and placed on two sets of stacked inclined gravity conveyors which feed the pistons to Operation 1 shown in this view. One set of six gravity conveyors feeds 4⅛-inch diameter pistons to six automatic lathes at the left, and the other set of six conveyors feeds 4-inch diameter pistons to six automatic lathes on the right. Each Sundstrand lathe is automatically loaded, bores the open end of the piston, faces and chamfers the bosses at the open end, and produces a center in the head end boss. As the pistons exit from the machine, they are checked by a Taft-Peirce gage and then fed onto the chain conveyor systems below the gravity conveyors.

pistons must be carefully handled in and between machining operations to avoid damage to their exterior surfaces. For example, nicks, scratches, and indentations can seriously affect performance in today's high compression engines. This is especially true of nicks at the edges of ring grooves since such defects are a detriment to the close fit of rings in the grooves and are likely to cause ring binding.

Prior to the installation of the extensive handling system shown in the accompanying illustrations, handling between production operations was accomplished in metal carriers that were pushed manually along monorail conveyors. The manual handling into and out of the carriers at the various machining operations caused excessive nicking of the pistons and involved much labor. Accordingly, Oldsmobile engineers devised the present handling system which incorporates as many automatic handling arrangements as were economically feasible. The system has yielded substantial cost economies,

3

From the first operation, the pistons are transferred automatically to chain conveyor systems that elevate and store the units until required in Operation 2. Twelve Sundstrand lathes, six on the left and six on the right, turn the outside diameter of the pistons, finish face the head end, finish turn ring grooves, chamfer ring groove edges, and finish turn ring lands. Upon ejection from the lathes, the pistons pass through Sheffield multicheck gages and are discharged onto a steel belt conveyor immediately below the chain feeding conveyors. At the far end of the machine line, the steel conveyor feeds the pistons to an elevator unit which lifts the units to an overhead pallet conveyor system for distributing pistons to the next operation.



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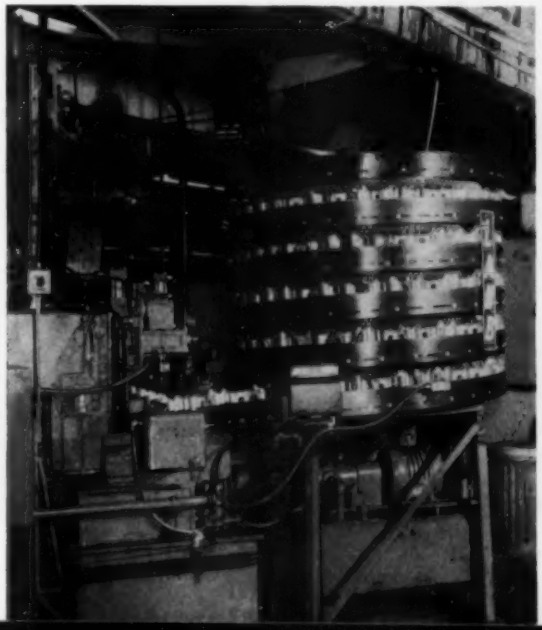
Operation 3 consists of three Impco transfer machines which drill two 5/16-inch locating holes in the open end bosses of each piston, rough bore the pin holes, and remove the center boss from the head end. Each machine will handle either size of piston so segregation is not necessary. The pistons feed from the overhead pallet conveyor into a Lamb helical storage chute at each machine as shown. After machining, the pistons are discharged with their open ends up onto a steel belt conveyor that carries the units to a loader of a washer where the pistons are inverted. The pistons are cleaned and dried in the washer, inverted again, and transported to a rotating sorter similar to one shown in Fig. 7. At this point, the pistons are separated automatically into 4-inch and 4⅛-inch diameter sizes, elevated to two overhead pallet conveyors serving one Morris and three Snyder balancing machines. Each balancer is preceded by a helical storage unit.

and many quality improvements have been attained. Foremost among these has been a large reduction in the number of pistons damaged in handling.

Basically, the handling system is a harmonious arrangement of different types of conveyors—gravity skate wheel, steel belt, chain, and track—which move pistons between production operations and furnish considerable in-process storage capacity. Additional storage capacity is provided ahead of some machining operations by helical storage chutes. Nearly all of the machine tools have been equipped with automatic load and unload devices which are fed by the conveying system. Two different diameters of piston—4 inch and 4⅛ inch—are processed in the system. In some equipment, segregation is not necessary and the two sizes are processed on a common conveyor. In other equipment, particularly in machine tools, the pistons must be segregated according to size, and this is accomplished by sorting devices at various locations.

Pistons enter the line as rough turned castings. During progression through the fourteen production operations, the pistons are turned to size, ring grooves are cut, piston pin holes are finished, the units are balanced, a coating of tin is plated to the outside surfaces, and the pistons are washed, check weighed, and inspected several times in the process. Acceptable pistons meeting all specifications are placed in trays, holding four units of a given outside diameter and piston pin hole size, and the trays are placed in inclined storage racks according to size classification.

A Teletype machine on the engine assembly line



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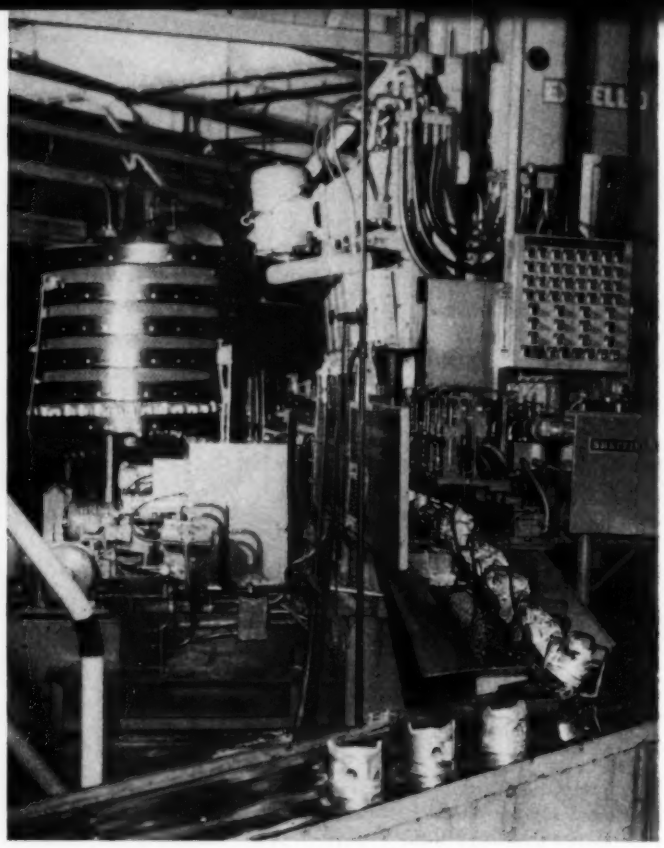
In each balancing machine, the weight of a piston automatically controls the setting of cutters which remove sufficient metal from the open end bosses to reduce the total weight to standard. The piston skirt is also faced to length in the balancing machine. The balanced pistons are then discharged onto a steel belt conveyor which maintains a separation between the two sizes of piston. Two elevator units lift the segregated pistons to pallets of a track distributing system for two Ex-Cell-O elliptic turning machines, shown, one Norton and nine Cincinnati elliptic grinders. These machines are fed by helical storage chutes and produce finished outside diameters that are elliptic (when the pistons are subjected to heat in service, the units become true cylinders). Each machine is set to turn a specified size so that stock racks can supply a range of sizes required for optimum fits at final assembly.

AUTOMATION TODAY



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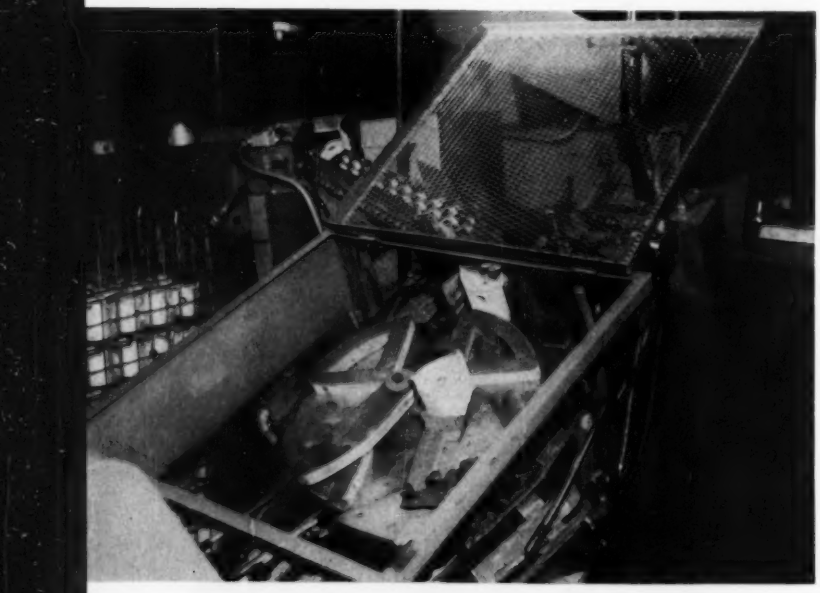
This is a view of the discharge end of one of the Ex-Cell-O turning machines. Each piston is inverted and righted during discharge to empty it of chips and cutting compound. Both sizes of pistons are then transported on a common steel belt conveyor to a Ransohoff washer and dryer unit at Operation 7. From the washer, the pistons are conveyed to a Stevens automatic plating machine which is loaded automatically with one piston per carrier. The carriers advance the pistons through the plating tanks which plate a specified coating of tin on the exterior surfaces. After automatic rinsing and drying, the pistons are conveyed to an automatic Sheffield inspection machine which checks all dimensions and rejects any pistons in which one or more dimensions are outside limits.

is used to inform an operator at the piston rack as to the sizes of cylinder bores to be fitted. The operator then loads the proper size pistons on a steel pallet conveyor. In transit to the engine assembly line, the pistons pass through a series of stations. Connecting rods are assembled to the pistons by means of piston pins. Wire rings are placed in lock grooves to secure the pins in the pistons. Then a special machine inserts a set of rings in the piston grooves. The subassemblies are then conveyed to the engine assembly line where each piston is inserted in its proper cylinder of mating size.



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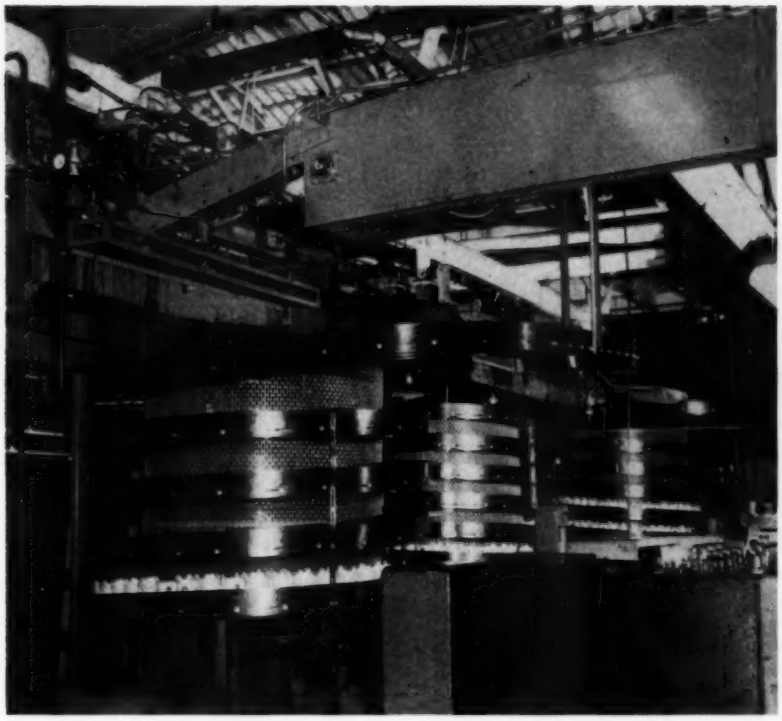
After inspection, the pistons enter this rotating sorting device for segregation into the two basic diameters. Pistons enter the device from the gravity conveyor in the center background. A 4-inch diameter piston will slide down one of the four slots and stop against the center hub. As the device rotates, guides hold the piston in this position until is slides by gravity into the chute at the lower left. A 4⅛-inch diameter piston can only slide part way down a slot and is held on the periphery of the device. As the device rotates, a guide causes the piston to slide into the chute at the lower right. The segregated pistons are then elevated to distributing conveyors which serve three Heald and four Ex-Cell-O boring machines at Operation 10.



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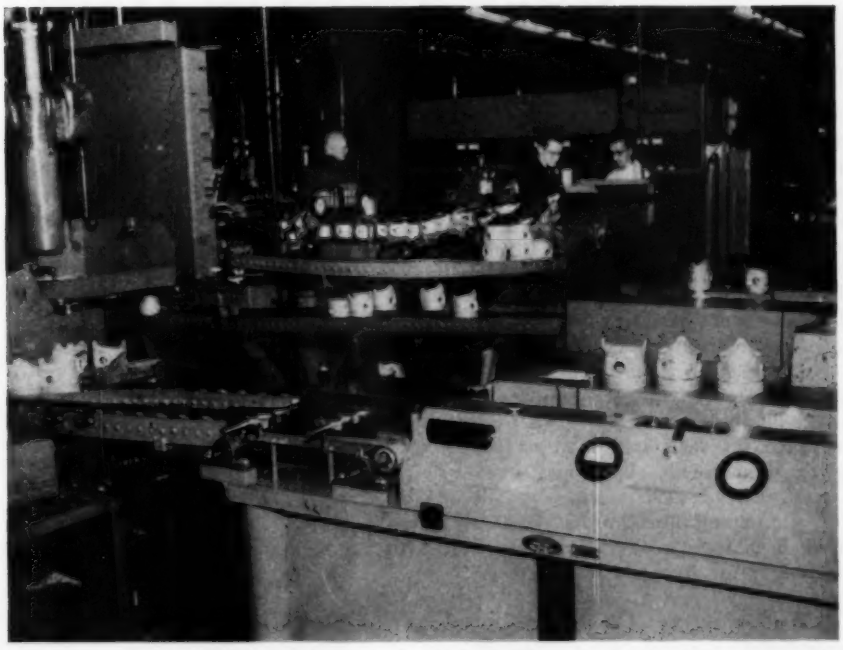
The boring machines at Operation 10 are fed by helical storage chutes of which three chutes are shown in this view. The seven machines turn the lock ring grooves and finish bore the pin holes in the pistons. After machining, the pistons are discharged onto a steel belt conveyor and conveyed to a Ransohoff washer and dryer. Still segregated, the two sizes of pistons are next conveyed to Hesco machines which bearingize the piston pin holes at Operation 12.



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Two Exact Weight machines in the foreground automatically check the weight of pistons at Operation 13. Over and under weight pistons are rejected and accumulated on gravity conveyors. Acceptable pistons are conveyed to either an R.C.A. or a Sheffield automatic inspection machine in the background where final gaging of all dimensions is accomplished. Again, off-size pistons are rejected, and acceptable pistons are classified and segregated according to outside diameters and pin bore sizes. Pistons are then conveyed to a platform where each unit is inspected visually for nicks, especially at the ring grooves. Acceptable pistons having the same outside diameter and pin hole sizes are then placed in trays and stored in racks awaiting assembly.

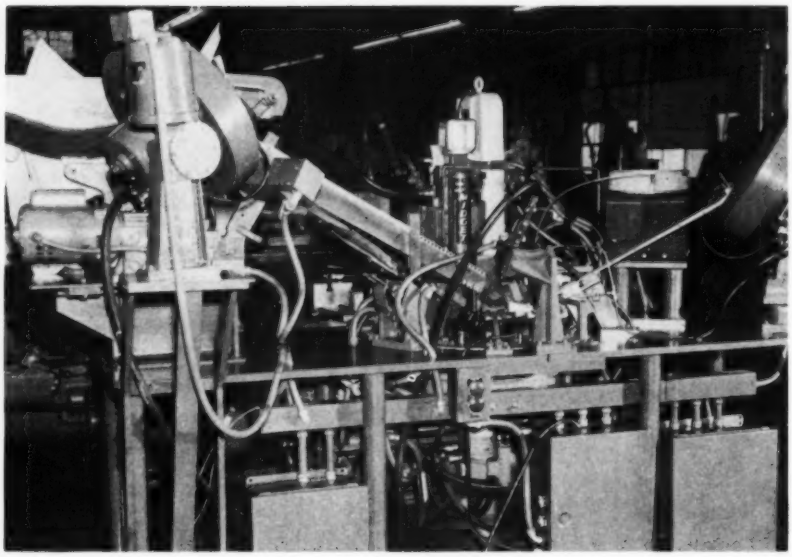


Fig. 1 — Automatic machine built around a 12-station index table on a Denison Multipress assembles 30 spring tensioners per minute. Each assembly includes four component parts held together by a crimping operation performed by the hydraulic press.

ASSEMBLY MACHINE USES TILTING NESTS

SMALL HARDWARE items offer one of the most fertile areas for application of automatic assembly. Such items that are now assembled automatically include the spring tensioners produced by Unique Balance Co. for use on double-hung windows. These spring tensioners provide an adjustable spring tension on double-hung windows, and allow the spring tension to be adjusted without removing the window from the frame.

The machine, *Fig.* 1, that assembles these spring tensioners at a rate of 30 per minute was designed and tooled by the Gros-Ite Co. The four different parts required for each assembly are fed by parts feeders to escapements above a rotary indexing table. The parts of each assembly are locked together by a crimping operation in a hydraulic press. The 31-inch table is a 12-station unit built with the crimping press by Denison Engineering Div., American Brake Shoe Co. Each station on the table is fitted with a tiltable nest, *Fig.* 2, to progressively receive the parts of an assembly.

The tilt-up nests were used to facilitate loading of the parts into the nests. Each nest is in the tilted up position to receive the ferrule, base arm, and slotted washer for an assembly. The nest is dropped

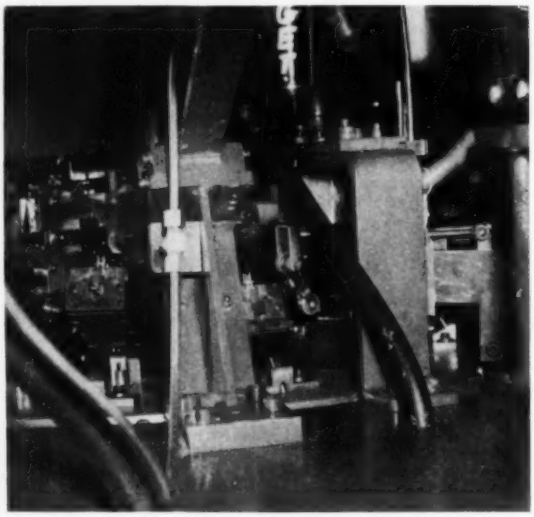


Fig. 2—View taken at washer inserting station illustrates the use of tiltable nests to facilitate part loading on the spring tensioner machine. As shown at left, each nest is tilted up by a push rod actuated by a cam under the index table. After a ferrule, base arm, and slotted washer are placed in the nest, it is dropped to a horizontal position as shown at center of photograph. Insertion of a spring and crimping to complete assembly are performed with the nest down.

to a horizontal position to receive a coil spring. The nest remains in the lowered position for the crimping operation.

In operation, one man controls the complete assembly cycle. His function is simply to turn the hydraulic press unit *Off* or *On* and to supply components to the feeders. Four feeders are used. A rotary ring unit built by Detroit Power Screwdriver Co. feeds ferrules down a track to Station 2, *Fig.* 3. An oscillating blade type feeder built by H. P. Townsend Mfg. Co. supplies base arms to Station 4. Slotted washers are fed to Station 6 by another Detroit rotary ring unit. Springs are fed through a tube to Station 8 by a vibratory bowl feeder using a unit built by Syntron Co.

The press, which crimps the end of the ferrule to complete the assembly, is a one-ton hydraulic unit. The hydraulic action of the press ram is set to apply just the necessary pressure to crimp the end of the ferrule but not enough to upset or bulge the ferrule stem. A depth control is set after testing for the desired ram pressure. The depth control regulates the length of ram stroke and reverses the ram when preset depth is reached.

Interlocks are used at several points to check on proper functioning. Between Stations 12 and 1 a limit switch checks to be sure the previous assembly was ejected from the nest. At Station 3 a limit switch checks for proper positioning of the ferrule in the nest. Between Stations 7 and 8 another limit switch checks to see that the nest has been lowered. At Station 9 the component buildup is checked before the ferrule is crimped in Station 10. On each feeder track there is a detecting device to determine whether or not a part is in position for placement in the nest. If any check indicates an improper condition, the machine is automatically stopped until corrections are made.

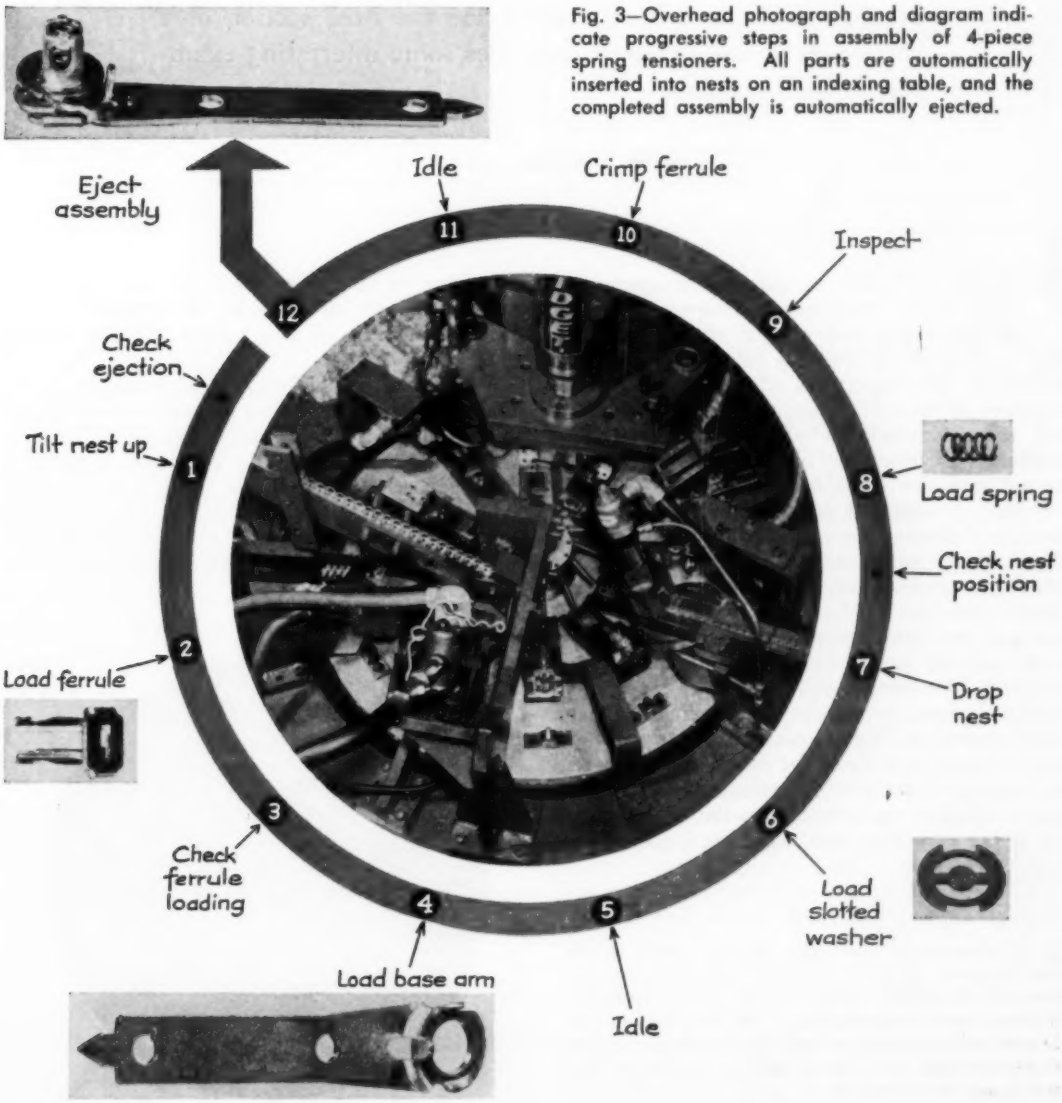
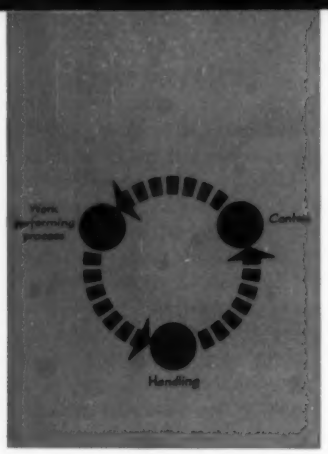


Fig. 3—Overhead photograph and diagram indicate progressive steps in assembly of 4-piece spring tensioners. All parts are automatically inserted into nests on an indexing table, and the completed assembly is automatically ejected.



PART 3—CONTROLS FOR

AUTOMATED PRESSWORKING

Actions of presses and associated handling equipment must be automatically co-ordinated and monitored for successful automated operation. Many automatic pressworking control arrangements have been applied. As the final section of a three-part series, this part describes some interesting examples of such controls.

By **LEE D. MILLER**, Associate Editor

WHEN PRESSES are expected to operate at speeds faster than operator reaction times or without step-by-step manual control, synchronized cycling of all elements must be automatic. Because of the importance of operating with a minimum of hazard to operators, equipment and work, safety interlocks and shutdowns must also be automatic. Developments in controls have therefore received extensive consideration.

A basic development for press control has been the type of element known as a rotary limit switch. Where several independently actuated motions are involved in pressworking operations, the rotary limit switch provides synchronized electrical switching, to initiate and terminate actions in sequence. Driven mechanically from the crankshaft of a press or in time with the press cycle, the switch selectively opens and closes contacts in several circuits at adjustable points in the press stroke. An early version of such elements is shown in *Fig.* 27. In that rotary switch, nine individual switches are mounted around a helical cam driven from the press. Rotation of the cam trips each switch at a given time according to the adjustment of that individual switch. Rotary switch units are available as integral equipment on new presses and also as separate components.

When it is possible to have some margin in the timing between independent actions, synchronization may be allowed to vary within given limits. In such a case, each element in the integrated installation may be cycled continuously until it reaches the limits of timing with respect to the slowest element that might interfere with it. The fast element must then be stopped until the slower element catches up.

Fig. 27—Sequential switching device, mechanically driven by press, provides electrical control actions synchronized with desired points in press cycle. Particular unit shown was developed by E. W. Bliss Co. to provide nine independently-set switching functions. Rotary limit switches are available as built-in equipment from many press manufacturers.

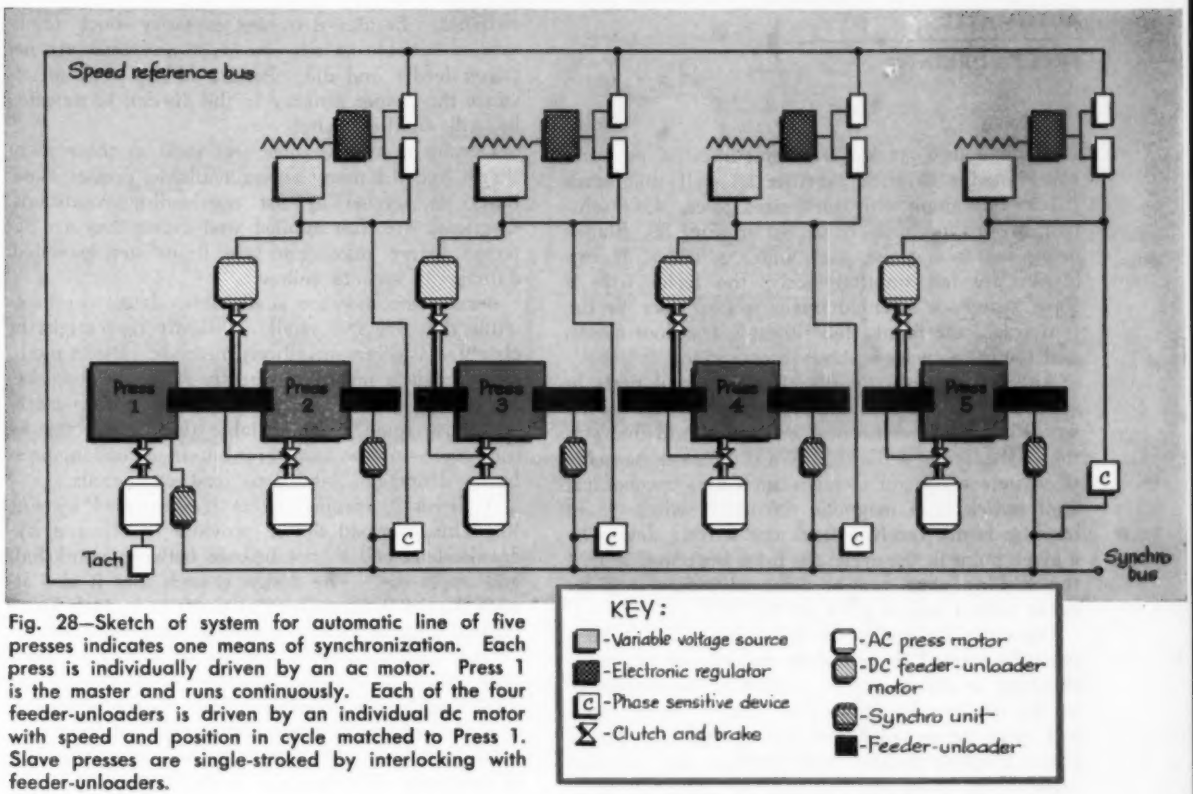


Fig. 28—Sketch of system for automatic line of five presses indicates one means of synchronization. Each press is individually driven by an ac motor. Press 1 is the master and runs continuously. Each of the four feeder-unloaders is driven by an individual dc motor with speed and position in cycle matched to Press 1. Slave presses are single-stroked by interlocking with feeder-unloaders.

By use of such a control system, some stops and starts of individual elements can be eliminated and associated wear on drive components reduced.

More elaborate control schemes have been applied to synchronization of lines of high speed presses.* One plan, *Fig.* 28, runs a master press continuously. Independent feeders for each of the presses in the line are individually operated by dc motors with speed and position in the cycle matched to the master. All other presses in the line are single stroked in time with their feeders.

A second type of system is based on variable speed drive of each press in the line with speeds and positions matched. Feeders for each of the presses are mechanically driven by their respective presses.

A third, even more elaborate, control scheme combines the two previous methods. Presses and feeders are each independently driven by variable speed drives with speeds and positions matched. This very flexible method allows all presses and feeders to run continuously.

As with any other automatic equipment, automatic checks for proper operation are applied, as required, to be sure that each element reaches given positions by given times in the cycle. Limit switches of all types are used to sense complete advance and complete retraction of loading arms, transfer bars, clamping fingers, die lifters, extractors, etc. With improved clutches and brakes that are available, such as the widely used pneumatic units, electrical signals indicating malfunctions can trigger fast clutch and brake action to prevent severe damage.

*G. M. Sommer, "Synchronizing High-Speed Press Lines: Five Methods For Increasing Productivity," 21st Annual Machine Tool Electrification Forum, Westinghouse Electric Corp., April 1957.

▶ Preventing Overload Damage

One of the critical points in most press operations is the fact that a setup can usually accommodate stock only up to given maximum dimensions. Because of this fact, variations in stock dimensions, simultaneous feeding of two or more pieces, or non-ejection of a preceding piece can cause serious damage to dies and even to the presses themselves. Though the presses may be protected by shear collars or shear pins, such last ditch measures seldom protect the dies, and usually require extended interruption of operations for repair. Where a press is being manually fed, the operator acts as an observer to note potential overload conditions. But if a press is automatically fed, or operates at high speed, protection from these malfunctions must be automatically provided.

A first step in such protection is to avoid the accidental feeding of more than one blank or piece into the dies at one time. Feeders and escapements for discrete pieces are designed to avoid such double feeding. Overhead magnetic or suction elements, for instance, are designed to pick up only the top

item on a feed stack. But sometimes oil or burrs cause blanks to stick together so well that extra blanks ride along with the desired piece. One solution to this problem is shown in *Fig.* 29. Blanks being fed to a press pass under a feeler. If two blanks are fed simultaneously, the feeler trips a limit switch; a solenoid opens a trap door in the feed track; the blanks fall through; the door closes; and the press cycles without interruption.

Another measure to prevent stacking of parts in a die is to ensure that the preceding part leaves the workstation before the next one is fed into that station. Passage of a part out of a station can be made to actuate a control element such as a mechanical limit switch or a magnetic proximity switch. If an impulse is not received from the sensing device by a given point in the cycle, the press is stopped so that the sticking piece can be removed before it is hit again with a second piece on top of it.

Especially for workpieces which have already been partially formed in preceding operations, automatic checking to ensure proper seating of the workpiece in the die can be important. This type of interlock may be provided through strategically placed pins. Properly located work contacts the pins and causes them to actuate switches. Or magnetic proximity detectors can be placed so that a part must be properly placed before a signal is generated.

When coil or flat strip stock is being fed into a press, several other safety switches may be applied. A switch actuator may roll on the stock to detect the end of a coil or strip. Variation of stock width beyond predetermined limits can actuate other switches. Besides detecting excessive stock thickness, a suitable switch can sense any buckling between feeder and die. Failure of the stock to advance the proper distance in the die can be detected by still another switch.

Despite preventive measures such as those mentioned and the many others available, presses sometimes are cycled against overloading conditions. Overloads are thus applied, and unless they are detected before maximum safe limits are exceeded, damage is sure to follow.

Several methods are available to detect overloads while they are still small. Basically they might be classified as direct or indirect methods. Direct methods provide a means to directly sense the force being exerted on the ram or slide. The indirect methods sense some other variable that is affected by that force—motor load, crankshaft deflection, press frame distortion, vibration, load on tierods.

A direct hydraulic system is illustrated by *Fig.* 30. This overload device provides in effect a hydraulic load cell in the linkage between crankshaft and upper die. The design is such that it also allows the die to be stopped as much as ½ inch above normal bottom without stopping the press drive.

One indirect system applied to a forging press also warns of eccentric loading even though the total load is not excessive. This system is applied to a press of tie rod construction. Essentially it provides four hydraulic load cells, one at each corner of the press. Comparison of the loads on the individual cells automatically indicates off-center loading effects.

▶ Programmed Presswork Controls

Much presswork is performed on large workpieces which must be repositioned for several hits in the same die or a sequence of operations with interchangeable dies in the same press. In addition to general pressworking requirements, automated press brakes and turret punch presses that perform such operations require selective positioning and sequencing controls.

The hydraulic press brake shown in *Fig.* 31 incorporates several positioning controls that illustrate some interesting possibilities in such equipment. This large press can form plates measuring 10 feet by 40 feet. Desired shapes are generated by successively positioning a plate in the press as the ram is repeatedly brought down to predetermined positions. Each end of the ram is independently powered, and the angle between the ram and bed is selectively controlled to obtain required forming actions.

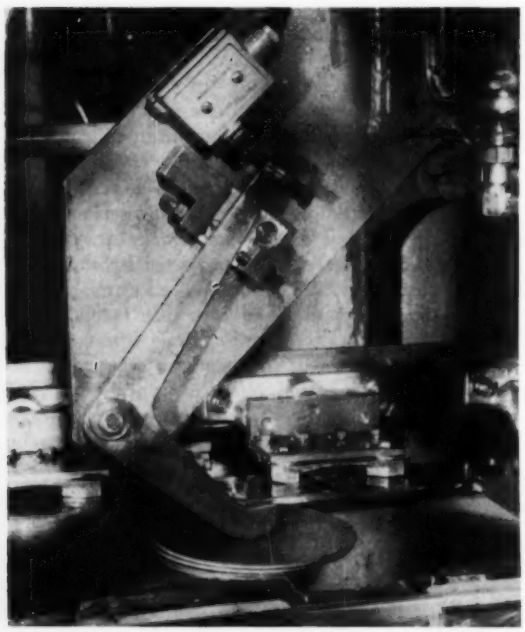


Fig. 29—Double blank detection arrangement allows automatic press built by E. W. Bliss Co. to cycle continuously without damage even though two blanks may stick together and be fed into transfer mechanism. Excess height of double blank causes feeler arm to trip a limit switch, a solenoid operated trap door is opened, and the blanks fall through.

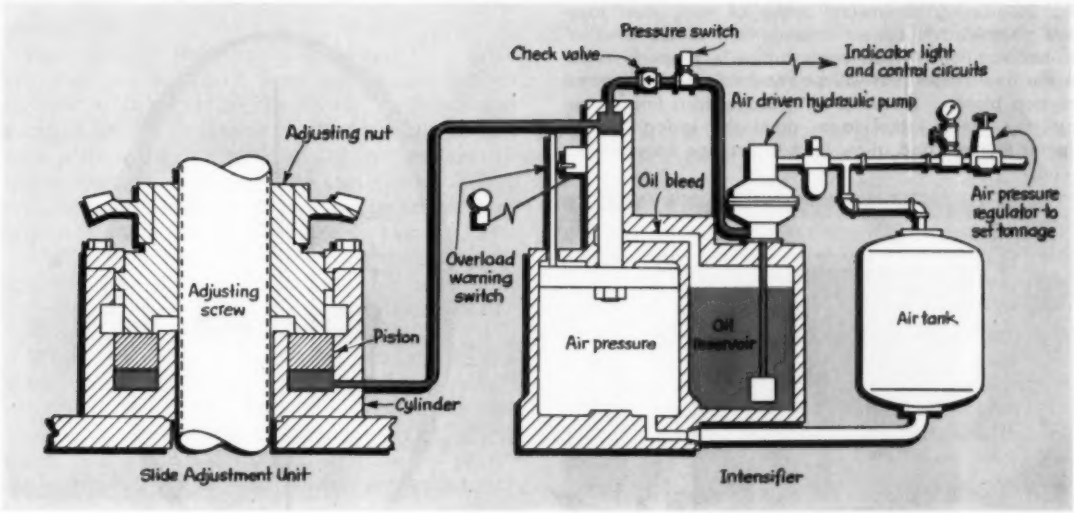


Fig. 30—Overload protection devices such as shown in diagram have been built into presses by Clearing Machine Corp. In effect the design provides a hydraulic load cell that can actuate an alarm device. Also, by telescoping ½ inch under excess load, the device can allow the press drive to continue moving even though the slide is prevented from bottoming.

Three very interesting types of control systems are used in that press. One of these controls the feed tables that advance the plate into the press. Another adjusts stop blocks at each end of the press to accurately establish the bottom position of the ram. The third system automatically adjusts the ram angle as the ram descends.

Positioning of the plate being worked is controlled by photoelectric systems actuated by steel tapes prepared for the particular workpiece to be formed. Each end of the plate is independently positioned by a feed table. The drive system in each feed table is controlled by one of the photoelectric systems. The control tape for a feed table is advanced

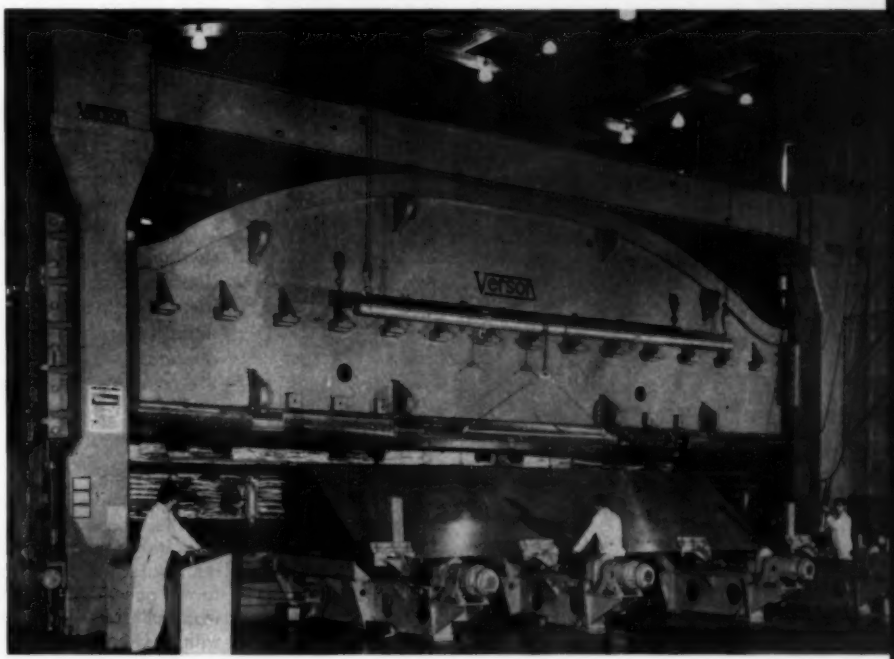
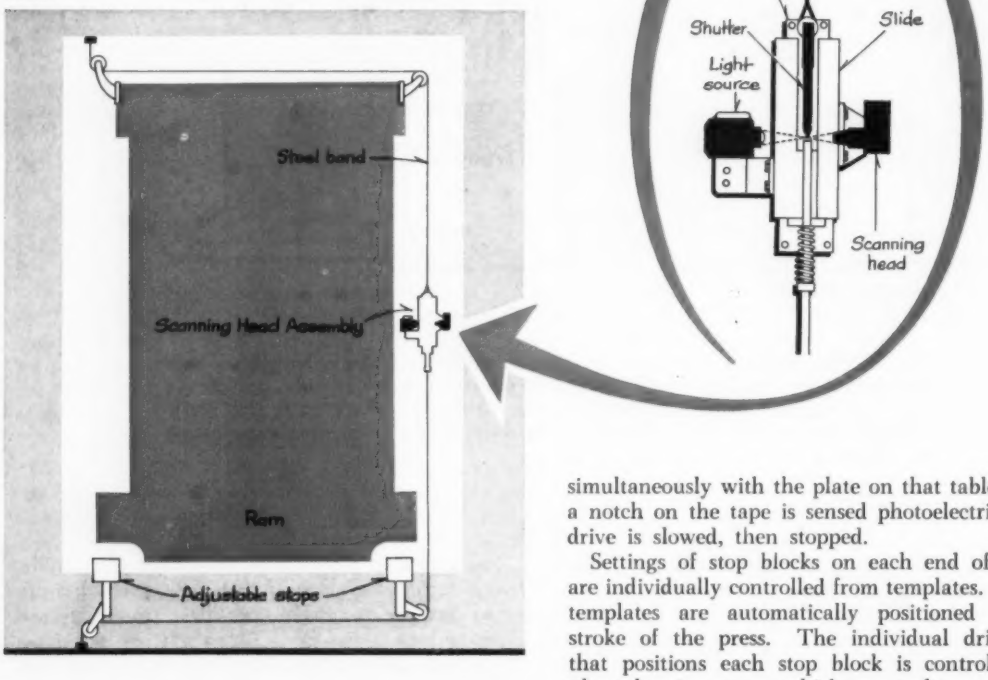


Fig. 31—Large plate is being loaded into hydraulic press brake which features automatic positioning of work in dies, adjustment of ram tilt, and adjustment of stops determining final ram position. Photocells are used to sense desired adjustments indicated by templates and steel tapes. Built by Verson Allsteel Press Co. this press brake has a bolster area 4 feet by 44 feet.

Fig. 32—During downward stroke of ram, steel tape and photoelectric system arrangement senses whether or not ram on Verson press brake is properly tilted to the final angle that will be reached when it bottoms on stop blocks. If ram is not parallel to a line across the stop blocks, steel tapes open the spring loaded shutter element and allow light to impinge on scanning head.



simultaneously with the plate on that table. When a notch on the tape is sensed photoelectrically, the drive is slowed, then stopped.

Settings of stop blocks on each end of the ram are individually controlled from templates. The two templates are automatically positioned for each stroke of the press. The individual drive motor that positions each stop block is controlled by a photoelectric system which stops the motor when desired height indicated by the template is reached.

As the ram moves down for an operation, its tilt with respect to the bed is adjusted so that it will meet the work at approximately the desired final angle. Once again a photoelectric system is used, *Fig.* 32. It determines whether the ram is parallel to a line between the tops of the two stop blocks. If they are parallel, two tapes, passing around rollers on the ram and stop blocks, are just long enough to meet and cut off a light beam.

In the case of a turret punch where a great number of work positions and selective use of several tools are required, control from punched paper tape has been applied, *Fig.* 33. Numerical control was used to accomplish accurate turret and work positioning at high speed and allow more hits per minute. The particular unit shown is expected to reduce the user's costs by $48,000 in the first year of operation. It is specified to make 30 hits per minute, moving the work an average of 4 inches along each of two axes per hit, and rotating the turret

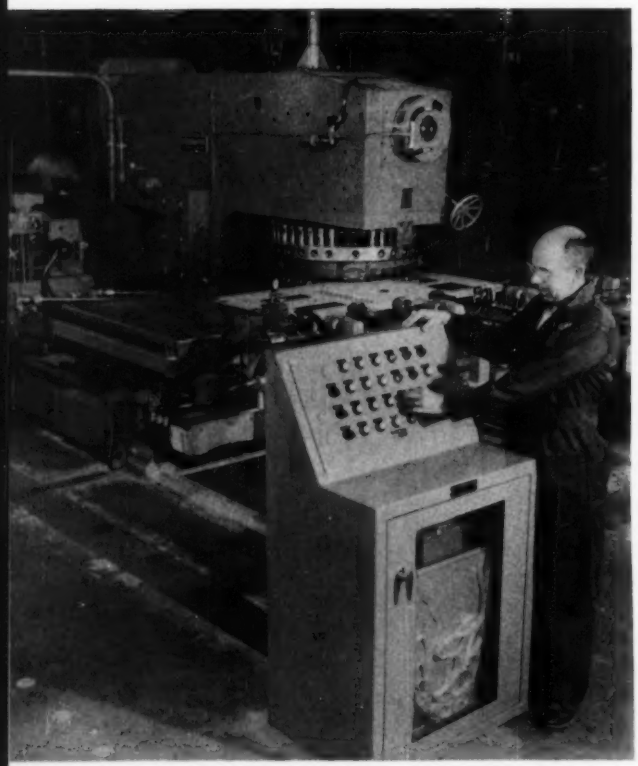


Fig. 33—Automatic turret punch press is controlled by punched paper tape. The press automatically moves work to desired positions along two axes, rotates turret to place desired tools in working position, and performs punching operations. This automated machine was built by Wiedemann Machine Co. and equipped with a General Electric Co. control system.

an average of 30 degrees approximately 3 times per minute.

Positioning of the plate is performed by a table unit that can be moved from side to side and in and out with respect to the turret. A paper tape punched in the engineering offices records desired work position for each stroke of the press. When this tape is inserted in the machine control console, the press operations can be automatically carried out. Hydraulic cylinders move the table along its two axes of motion. Selsyn type units generate signals indicating the position of the table at a given time, and control action is taken to make these position signals equal to the desired values.

While the work is positioned, the upper and lower turrets are indexed automatically to present the desired punch and die in the working position. The turret construction allows mounting of 36 different punch and die sets and selective use of any set by rotating the turrets. Turrets are turned by a hydraulic piston motor, and another selsyn arrangement provides turret position signals. These signals are compared to commands also punched in the paper tape, and the control system seeks to balance them.

▶ No More Frontiers?

As the examples noted in this article indicate, a wide range of equipment and technology is available for all three phases of pressworking—work performing, handling, and control. Nearly any press shop could improve its operations by applying more broadly the equipment and know-how presently available.

This does not mean that further developments in pressworking are either unnecessary or unlikely. As the improved equipment and methods now available are more widely applied, further process improvements will be demanded. Familiarity with the presently available techniques will lead to contempt for some of their details.

Considering the continuing developments that have taken place in press drive elements, it is not difficult to predict that more are yet to come. Stock preparation equipment will surely see more developments; perhaps each press line will be equipped with its own ultrasonic cleaning unit to process the stock as it is fed from the coil. Handling devices will become more useful as they are developed to be more versatile and more speedily adaptable from job to job.

Automatic inspection has seldom been applied within press lines. Some beginnings have been made though. At least experimentally, ultrasonic flaw detection has been used to mark bad blanks as they are made. Perhaps scanning equipment will become commonplace to detect tears or bad wrinkles in drawn parts and eject them before succeeding operations. Automatic checks for die wear or punch breakage may be made to eliminate operator oversights, because an automatic line can make out-of-tolerance parts at the same fast clip at which it can make good parts.

Even if further developments are a long time a-borning, manufacturing engineers have tremendous production potentials available through pressworking. There is little doubt that they will continue to apply them advantageously.

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are you stuck?

Since its inception AUTOMATION has helped increasingly in the solutions of hundreds of widely diversified practical problems in making manufacturing operations more automatic. Regardless of the character of the operation or system being developed, somewhere in industry a similar problem has been solved and, very often, equipment is available from reliable builders or suitable techniques are known to specialists.

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POWER MEASURING DEVICE CONTROLS MATERIALS FEEDING

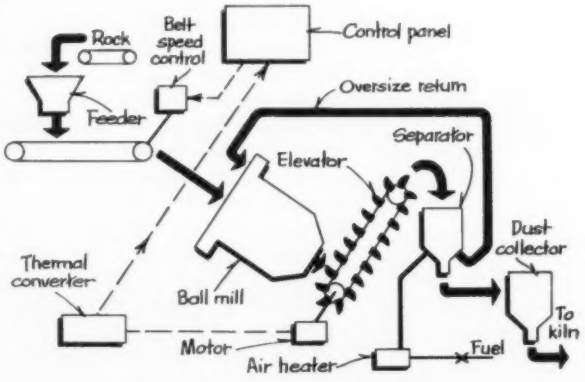
IN THE CEMENT INDUSTRY, fineness of raw material pulverization must be carefully controlled to assure desired finished cement properties such as setting time, strength, and composition. Two methods of pulverization are commonly used, both employing ball-type grinding mills. One method, known as wet processing, grinds the raw materials in the presence of water into a slurry. The second method, known as dry processing, pulverizes the cement rock and shale to a fine powder. This is fed to an air separator where oversized particles are removed and recirculated back to the ball mill for additional grinding. Such a grinding process is used at the modern plant of Louisville Cement Co. to prepare raw materials for cement manufacture. The ground materials are subsequently burned in kilns to form clinkers which are ground with other materials into cement.

Two 13-foot diameter by 16-foot long ball-type grinding mills are used to prepare raw materials for burning in the company's kilns. Crushed stone and shale from quarries are stored in silos until needed in the grinding process. These materials are fed into the grinding mills by means of belt conveyors. After grinding, the fine powder is discharged into a dual set of elevators at each ball mill and delivered to each system's air separator. Properly sized material is then separated and delivered to the kilns, and large particles are returned to the ball mills for further grinding.

To maintain optimum raw material loads in the mills, application engineers of Leeds & Northrup Co. co-operated with Louisville Cement engineers in designing an electrical control system to regulate the drive motors of the belt conveyors feeding the grinding mills. Analysis had shown that the electrical load on the motors operating the mill discharge elevators bore a direct relation to the load in the mills. Therefore, a measure of the elevator motor loads is used to control the mill feed rate and closely maintain the optimum mill loading.

The control system for each of the grinding mills is identical. Each ball mill has two elevators for removal of discharged material. Each elevator is driven by a separate motor to which is connected a thermal converter for measuring the kilowatt load drawn by the motor. The output of the converters is wired so that either unit can be connected to a recorder-controller on a central control panel or both converter outputs can be averaged for mill load control. The recorder-controller receives the electrical signal from the converters and, through a motor-operated drive unit, regulates the speed of the feed conveyor motor. By automatically controlling the feed rate into the grinding mills so that optimum loads are processed at all times, the company has increased the output of the mills by about 75 barrels of ground material per day.

The control panels for the two ball-type grinding mills are located on a balcony above the plant floor. The left panel controls one mill, and the right panel controls the other mill. Other instrumentation on the panels includes: Recorders for separator intake air and air heater discharge temperatures, recorders for the feed rates of raw materials from storage silos, totalizing digital indicators showing total amounts of feeds, banks of panel alarm lights to indicate malfunctioning of the materials handling system throughout plant, ammeters which indicate current drawn by various motors, level indicators which show levels of raw materials in silos, and 16-point recorders which continuously plot various bearing temperatures on the grinding mills, feed journals, and air separators.



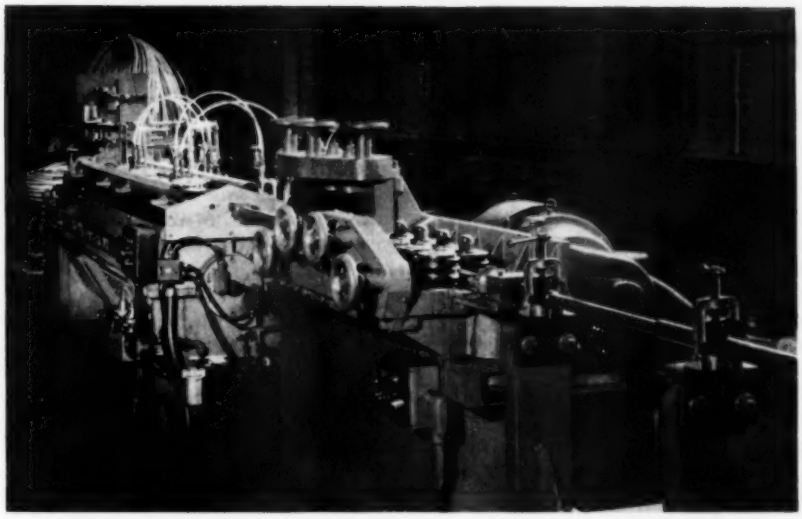


Fig. 1—Uncoiler in left background supplies rod stock to pre-straightener, continuous drawbench, and straightener shown in that order. Stock passes through pipe at right to a flying shear. The drawbench continuously draws stock through a die at the rate of 200 feet per minute.

INTEGRATED ROD DRAWING

KEY TO CONTINUOUS BAR PRODUCTION

COLD FINISHED bars are a widely used form of steel stock generally produced in small sizes from coiled rod stock. In a typical procedure, coils of hot rolled, pickled, and limed rod stock are moved through separate operations for drawing, straightening, polishing, and cutting to length. Now, Loma Machine Mfg. Co. Inc. has built an integrated continuous line to perform all these operations for an Eastern steel mill.

The continuous line is capable of turning out high-quality cold finished round, square, hexagonal, and rectangular sections in sizes from 3/16 to 5/8 inch. Production rate is 200 lineal feet per minute. In the production of 5/8-inch rounds, this speed results in an output capacity of 5 tons per hour, taking into account 20 per cent downtime for coil feeding and tooling changes.

The line includes an uncoiler, a pre-straightener, a continuous drawbench, a roller straightener, a flying cut-off shear, a polishing machine, and a discharge table. The polishing machine and discharge table are only used for rounds; other shapes are discharged into piling racks after being cut off. Elements in the line are interlocked mechanically and electrically into a single integrated and synchronized unit which is controlled by a single operator.

Advantageous features of the integrated line include: 1. Continuous operation at high speed. 2. Requirement of only one operator. 3. Straightening of stock in two planes. 4. Highly finished surfaces on stock processed.

Line Operation

The operator points the lead end of each coil on a swaging or turning machine and uses auxiliary handling equipment to load a coil on the uncoiler. The point is inserted into the 5-roll pre-straightener which removes coil bend and eliminates kinks. The rod then passes through a tungsten carbide die on the drawbench, *Fig.* 1. Reduction in the draw die improves surface quality and produces a closely held bar size.

Productivity of the line is largely due to the high-speed drawbench which can exert a continuous pull of 8000 pounds at the line speed of 200 feet per minute. The stock is pulled continuously through the die by reciprocating movements of two carriages with built-in jaws. The carriages are installed in series along the line of stock travel in such a manner that the stock passes over both carriages.

Movements of the carriages are actuated by cam tracks cut into two rotating drums under the carriages. The gripping jaws are closed and opened automatically by an electropneumatic system synchronized with carriage movements. Uniform continuous advance of the stock through the die is obtained by overlapping carriage actions.

Emerging from the drawbench, the rod passes through a vertical roller straightener and a horizontal roller straightener. Each roller straightener includes eight rollers, four of which are positively driven by a single motor through gearing. Rollers

are mounted on overhung shafts. Such mounting simplifies adjustment and changing of rollers.

Straightened stock is cut into preset lengths from 8 to 25 feet by a flying shear, *Fig.* 2. The two cutters of the shear are mounted on slides in a shear carriage. The carriage advances and retracts along the line of stock travel. Advance speed is synchronized with line speed of the stock, and return speed is faster. When the carriage advances, levers linked to the cutters act in such a manner that the cutters approach each other until the cut is completed. The cutters open automatically at the end of the carriage advance and remain open during the carriage return.

Shear operation is initiated when the leading end of the stock trips a limit switch. The length cut off is determined by the distance between the limit switch and the shear carriage in its rest position. This distance is varied to obtain desired cut-off length by moving the entire shear along its supporting bed frame.

After being cut off, round stock is further processed in a combination straightening and polishing machine, *Fig.* 3. Bars are moved through the polishing machine at a speed greater than the drawing speed, so there is no interference between the two operations. Polishing is performed by conveying the bar between two pairs of motor-driven discs which press against the bar. The centers of the discs in a pair are offset from each other along the line of stock travel and are slightly below that line. The discs are rotated in the same direction, and the bar is given a combined rotating and advancing movement. The pressure of the discs acting on the stock as it moves in this manner produces a dense and polished surface of 20 to 30 microinch rms finish.

A precision straightening effect is obtained by passing the stock through three bushings which can be offset to cause controlled bending of the spinning bar in all directions, thus relieving any stresses and assuring straightness. The finished bar is discharged from the polishing and straightening machine onto a sloping table. When the rods roll freely down this slight incline, the operator can visually check them to be sure the straightener is correctly adjusted.

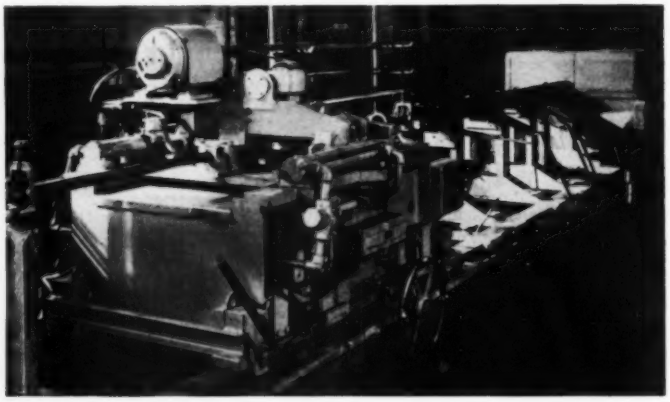


Fig. 2—Stock from the straightener enters the flying cutoff from the left of this photograph. Bars other than round stock are piled in racks after leaving the shear. Round bars advance into polishing and straightening machine at upper right.

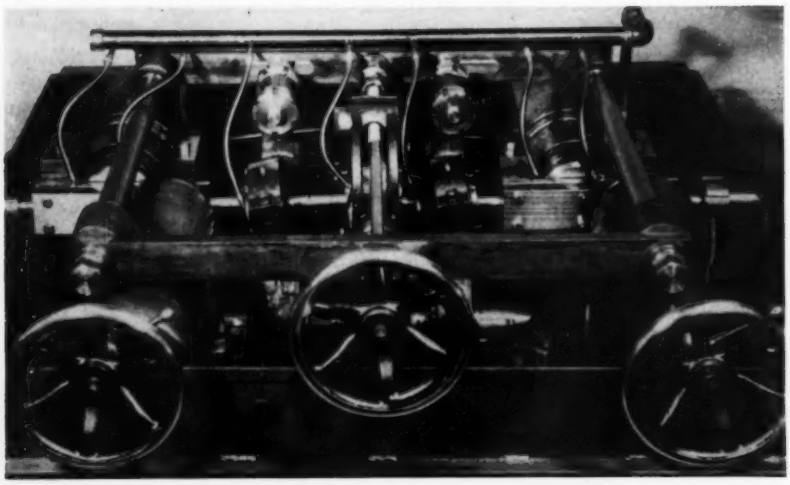
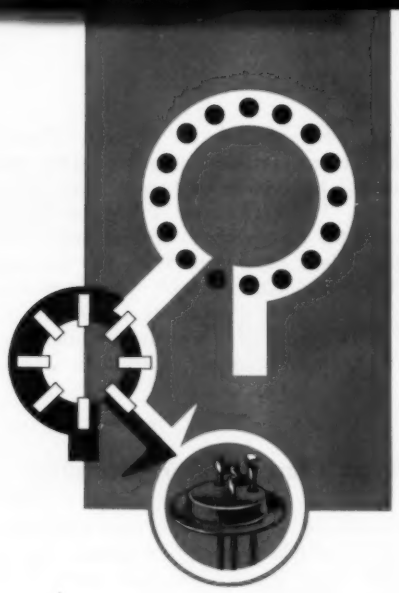


Fig. 3—View of polishing and straightening machine with covers removed shows bar passing through machine. Bar enters at left, passes between two polishing discs, through three bushings offset to effect straightening, between two more polishing discs, and out at right.



AUTOMATING TRANSISTOR ASSEMBLY

Deterrents to the development of automatic facilities for the assembly of transistors are many—extremely small components must be handled and positioned in small spaces, assembly operations are critical and must be precisely controlled, transistor design is constantly being changed and improved. However, the advantages of mechanized assembly are enticing—quantity production, quality product, lower costs. The development of a successful automatic assembly machine for transistors is described in this article.

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TRANSISTOR technology is still a relatively new art, and frequent improvements in design and performance can be expected as a result of broad and intensive development efforts by the many companies in the field. However, such progress has a price. Manufacturers can barely achieve economical production levels in one transistor design before scientists evolve an improved design requiring different manufacturing procedures. Therefore, although transistors are being manufactured today in considerable volume, their production remains essentially a series of manual operations by highly skilled operators using microscopes, oscilloscopes, micromanipulators, and other equipment of similar precision.

At the same time, new systems and equipment are constantly being designed which incorporate transistors. Operation of such new equipment is predicated on the availability of low cost, dependable transistors. Still broader applications of transistor technology are limited to a large extent by the volume in which transistors can be economically produced. As in any other manufacturing operation, manual techniques are not conducive to production at high volumes and low cost. Therefore, several months after Western Electric assembled its first "production line" transistors in 1951, an Engineering Development Group was formed for the express purpose of investigating manufacturing processes and developing facilities for the

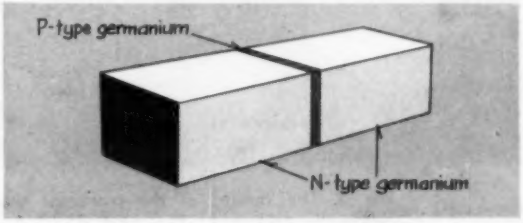


Fig. 1—NPN grown junction bar is only ⅛ inch long. The layer of P-type germanium is about 0.001 inch thick. The small size and brittleness make it difficult to feed the bars automatically.

high level production of transistors and varistors. One project undertaken by this group was the development of a machine to automatically assemble grown junction NPN transistors.

Design of Telephone Apparatus

The grown junction NPN transistor was designed by Bell Telephone Laboratories which is the research and development organization of the Bell Telephone System. An understanding of the relationship between Bell Telephone Laboratories and Western Electric may help to explain the co-operative effort required to place in production a newly-designed piece of telephone apparatus. The responsibility for the development of device and system designs lies within BTL up to a point where they are considered to be operable, manufacturable, and reliable. The responsibility for manufacture of the proved design lies within Western Electric. When Western Electric accepts a Laboratory designed device for manufacture, a co-operative effort between BTL and Western Electric starts at the "planning-for-manufacture" stage and continues as long as the device is used in the Bell System.

In recent years, the value of "preproduction" liaison between the two organizations has been recognized and simplified by locating resident BTL development groups in the various Western Electric manufacturing locations. With such an organization, it is possible to minimize the interval of time necessary for placing a new device into production. Co-operation between the device development engineers and the manufacturing engineers thrives under these ideal conditions.

When the design of the grown junction NPN transistor was released to Western Electric for manufacture, very modest quantities were involved, and manual production techniques were considered satisfactory. However, after the potential of the new transistor was realized, several large Bell System applications developed. With the increased requirements, automatic assembly was deemed a necessity. At this time, a thorough investigation as to the adaptability of the transistor design to high level mechanized assembly operations was undertaken.

Design Changes For Producibility

The heart of a grown junction transistor is a small bar of single crystal germanium, *Fig.* 1, into which has been "grown" a base layer of P-type germanium that is only 0.001 inch thick. This P-region is grown between two regions of N-type germanium which differ in resistivity by a factor of approximately 100 to 1. In the manually produced design, the $\frac{1}{8}$-inch long NPN germanium bar was soldered between two header leads whose offset ends had been formed, flattened, and tinned.

The header base and can of the original design of transistor were oval shaped, *Fig.* 2, and the three header leads were parallel to each other in the same vertical plane. In attaching the germanium bar to the header leads, the soldering, etching, and rinsing operations had to be performed in close proximity to the Kovar-to-glass seals of the header. This was undesirable since contamination and deterioration of the glass seals of the header were possible. Hermetic sealing by soldering in an inert atmosphere was considered to be an adequate environmental protection at that time.

Numerous design changes appeared desirable in order to adapt the transistor to automatic manufacture. Of prime importance to the manufacturing engineers was the replacement of the oval can and header with a round structure in order to effect

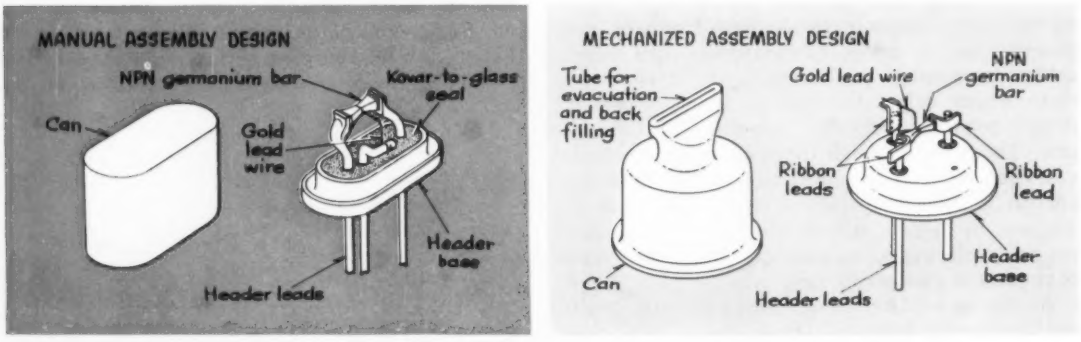


Fig. 2—The design of the transistor was physically changed in order to facilitate automatic assembly. The most significant change was the adoption of ribbon leads for attaching the NPN germanium bar to the header leads. This provided a means of supporting the bar in the machine fixture during processing and eliminated the possibility of contaminating the Kovar-to-glass seal of the header (in the new design, the seal is on the underside of the header base.

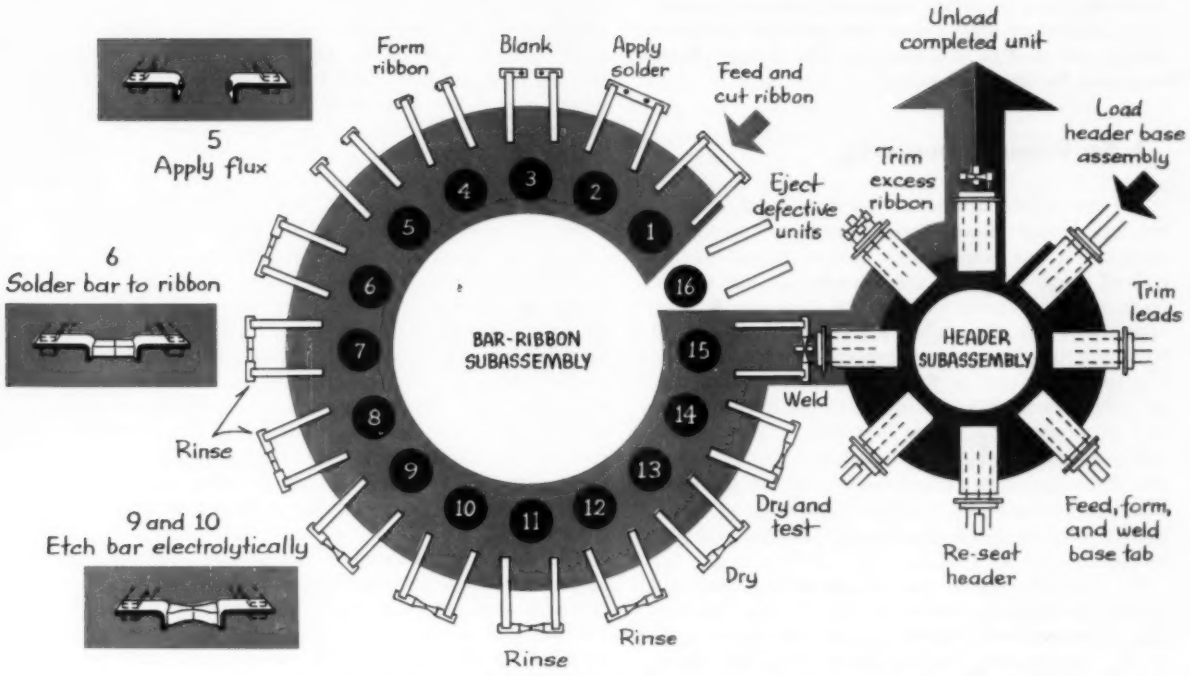


Fig. 3—Two rotary indexing tables are used in the transistor assembly machine. The NPN germanium bars are attached to ribbon leads, etched, and tested on the 16-station table, and the headers are prepared on the 8-station table. The two subassemblies are welded together at the point where the tables are adjacent to each other. Maximum output of the assembly system is approximately 240 units per hour.

economies in manufacture and tooling. To facilitate automatic handling of the NPN bar through the necessary operations of soldering, etching, rinsing, drying, and testing, it was decided to add ribbon leads between the ends of the germanium bar and the header leads. Although it is generally undesirable to increase the number of parts, this change was motivated by a desire to simplify manufacture. The difficulty of forming header leads to a precise dimension in order to fit the bars was eliminated in favor of straight leads and the easily formed ribbons. Also, by delaying assembly of the bar to the header until after all bar processing was completed, it was possible to test the bars and only weld the acceptable bars to the headers, thereby saving relatively costly headers. Adoption of ribbon leads also permitted a faster electrolytic operation and an electrical evaluation of the bar prior to its attachment to the prepared header. Since these operations could be accomplished prior to assembly to the header leads, all possibility of contamination of the header and deterioration of the glass seals was precluded.

In order to enhance the stability and reliability of the grown junction transistor, the Laboratories specified a vacuum bake out and oxygen back fill operation just prior to final encapsulation. This required a tubulated can which is welded to the header and pinched off after the vacuum pump and back fill operation.

▶ Establishing the Process

With the proposed design of the transistor in mind, the development of the sequence of operations and associated tooling necessary to economically manufacture the grown junction transistor was begun. A series of hand operated prototype tool and machine elements were provided to prove-in the basic concepts of the ultimate tooling, and to permit an evaluation of the new design of transistor. Several processing changes deemed essential for mechanized assembly were also investigated. After this tooling was debugged, an experiment was set up. Numerous lots of units were processed through the pilot line while NPN bars from the same grown crystal were processed through the manually operated production line as a control. In addition to the data taken at various stages of the assembly operations, life data were accumulated for the BTL reliability engineers.

Following completion of the pilot line experiment, all data and a quantity of "tool-made" samples were submitted to the Bell Telephone Laboratories for analysis. The proposed design of transistor was found to be satisfactory, and in some respects superior to the original design and process, from the standpoint of electrical parameters, reliability, and mechanical stability. It was recognized, too, that improved yields and narrowed spreads in both mechanical and electrical capabilities would be

achieved by a uniform, automatic assembly operation. Laboratory approval on the proposed transistor design and process was granted. The design of the automatic facilities was begun.

Bar-Ribbon Subassembly

For automatic assembly, the redesigned transistor was broken down into two subassemblies. Operations on one subassembly consist of forming the ribbon leads, soldering the germanium bar to the leads, electrolytically etching the bar, and testing. Operations on the other subassembly consist of trimming the leads of a prepared header, welding a base tab to one of the three leads, welding the bar-ribbon assembly to the other two header leads, and trimming the excess bar-ribbon leads. Two rotary indexing tables—one having 16 stations and the other having 8 stations—were used as the basic building blocks of the automatic machine. The sequence of operations on the two tables is shown in *Fig.* 3.

An over-all view of the completed transistor assembly machine is shown in *Fig.* 4. The bar-ribbon subassembly is started on the 16-station table at the first station, *Fig.* 5, which feeds the ribbon from a supply spool, cuts it to length, and loads it into the clamping fixture or carrying fingers of the index table. After preliminary processing on the table, this ribbon will become the ribbon leads to which the NPN germanium bar is soldered. The table is indexed automatically to the second station, *Fig.* 6, and two spots of solder are applied to the ribbon at the points where the germanium bar will eventually be soldered. The third station performs a blanking operation which removes a small portion of the ribbon between the solder spots. This operation separates the ribbon into two parts which will become the leads on each side of the germanium bar. At the fourth station, the ends of the ribbons containing the solder spots are bent 90 degrees, and at the fifth station a solder flux is applied to the formed ends.

The NPN germanium bars are prepared in another area of the plant and are delivered to the machine as completed units. They are loaded into a vertical magazine feeder at the sixth station, *Fig.* 7, and are automatically positioned between the formed and tinned ribbon leads as the carrying fingers are indexed into the station. Located beneath the carrying fingers at this station are two heating elements which are mounted on spring-loaded slides. At the proper moment, a cam raises the slides until the upper portions of the heating elements just contact the undersides of the formed ends of the ribbon leads. The spring-loaded slides then push the ribbon ends into contact with the NPN germanium bar, and the soldering operation is performed.

The next two stations, seven and eight, are rinse operations which flood the bar with deionized water to remove all traces of flux. The assembly is then indexed into the first of two etching stations, *Fig.* 8, where potassium hydroxide solution is used in an electrolytic etching process to remove that portion of the germanium bar which was damaged during the cutting and barring operations. This operation was one of the chief deterrents to the economic manufacture of the old design transistor because approximately $2\frac{1}{2}$ minutes were required for a satisfactory electrolytic etch. The germanium bar was attached to the header prior to this operation, and attempts to reduce the etching interval by increasing current density caused contamination and deterioration of the glass seals in the header.

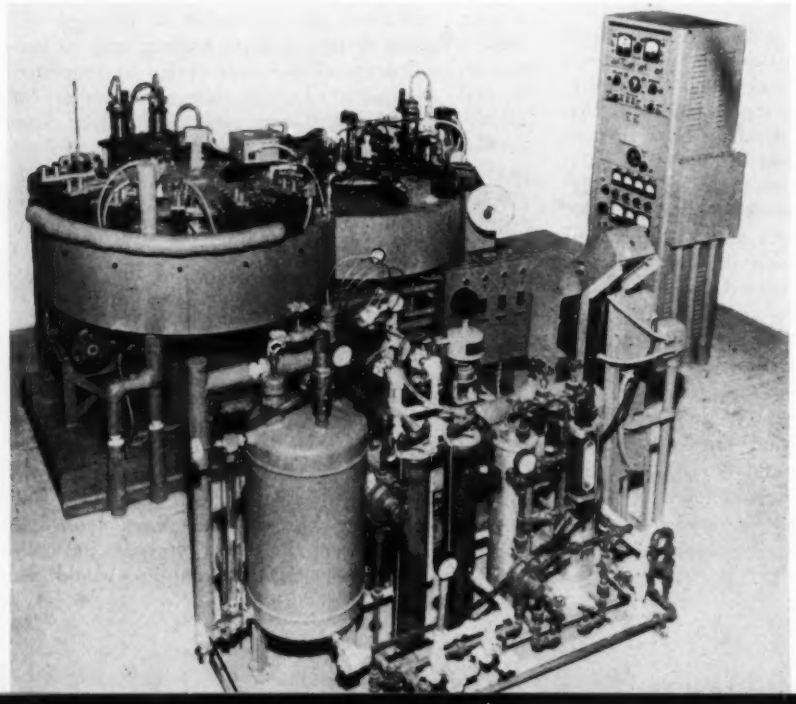


Fig. 4—The transistor assembly machine is shown in the background. In the foreground is auxiliary equipment associated with the machine. This includes an electrolytic etchant supply tank, water deionizing units, air driers, and piping for the low pressure air and nitrogen gas supplies. At the right of the picture is the control cabinet for the machine.

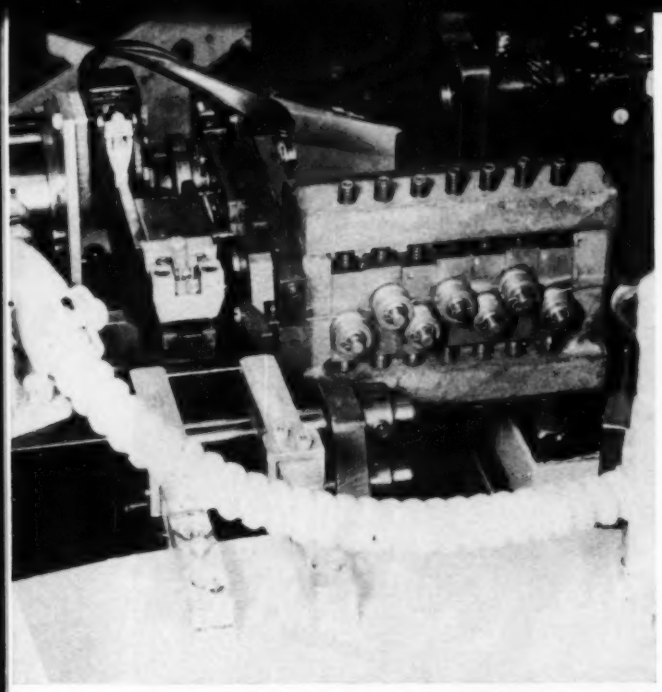


Fig. 5—At the first station of the bar-ribbon table, Kovar ribbon is fed from a supply spool located underneath the table, through the straightening rolls on the right, and into the inserting mechanism in the background. A cam causes the inserting mechanism to slide forward and position the cut ribbon in a clamping fixture on the index table. During this motion, two spots of soldering flux are deposited on the ribbon by the two Leroy lettering pens mounted on the inserting mechanism.

Since the new design was to be etched prior to assembly to a header, it was possible to increase the current density of the electrolytic process to a point where satisfactory etching required only 25 seconds. However, all other operations at the various stations could be done in less than 15 seconds. Therefore, two etching stations in series with each other were provided at the ninth and tenth positions of the index table.

The eleventh and twelfth stations are deionized water rinse stations to remove all traces of etching solution. The subassembly is then air dried at the thirteenth station. Each bar-ribbon subassembly is tested at the fourteenth station to prevent subquality units from being welded to the good headers. The electrical test compares the photoelectric properties of the subassembly to those of a standard quality transistor. When the bar-ribbon assembly passes this test, an electrical signal actuates a relay on the 8-station header table, allowing a header to be moved to the welding position common to both index tables (fifteenth station of the 16-station table and the sixth station on the 8-station table). If a substandard bar-ribbon is detected in the test station, the welding operation does not occur, and the faulty bar-ribbon unit is indexed to the sixteenth station where it is ejected.

▸ Header Subassembly

During the time that the bar-ribbon subassemblies are being processed on the 16-station table, header subassemblies are being prepared on the 8-station rotary table. When the header base assemblies reach this table, the three lead wires have been inserted in the base, aligned, and affixed via glass-to-metal seal. Assemblies are fed into the table fixture at the first station, *Fig.* 9. The assem-

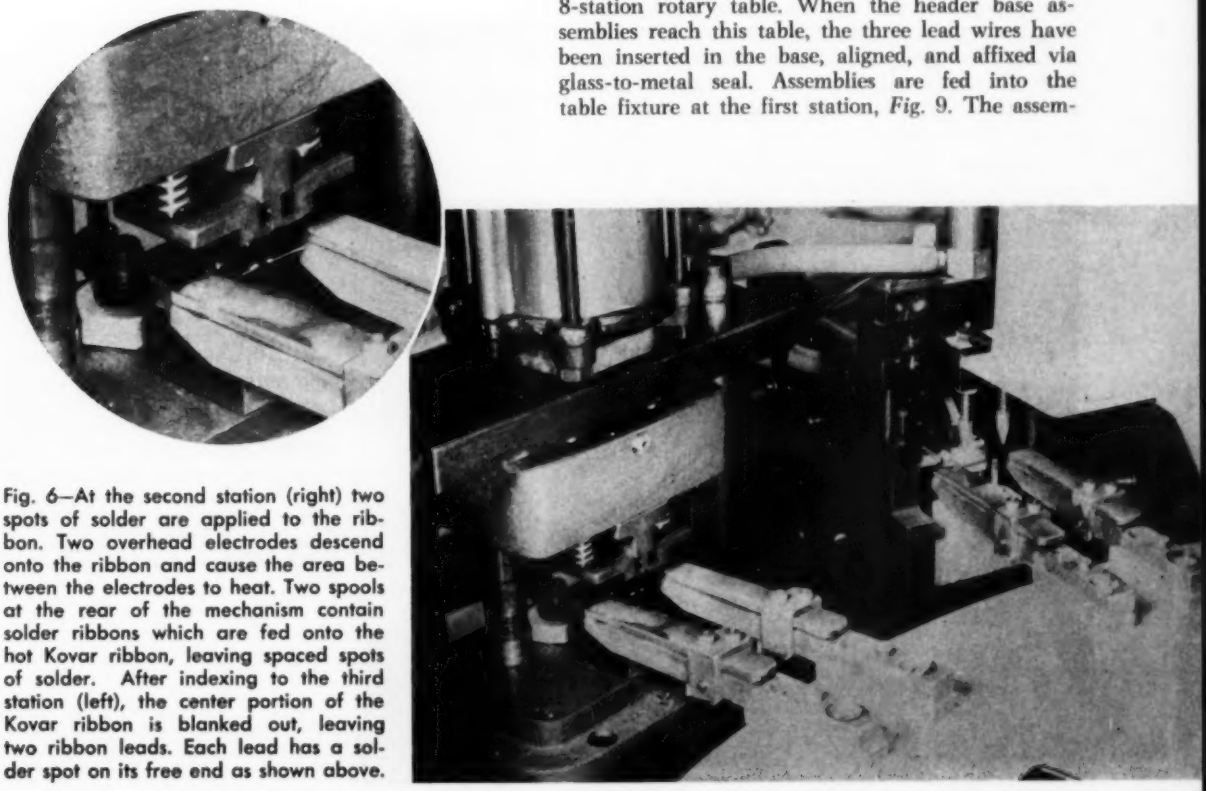


Fig. 6—At the second station (right) two spots of solder are applied to the ribbon. Two overhead electrodes descend onto the ribbon and cause the area between the electrodes to heat. Two spools at the rear of the mechanism contain solder ribbons which are fed onto the hot Kovar ribbon, leaving spaced spots of solder. After indexing to the third station (left), the center portion of the Kovar ribbon is blanked out, leaving two ribbon leads. Each lead has a solder spot on its free end as shown above.

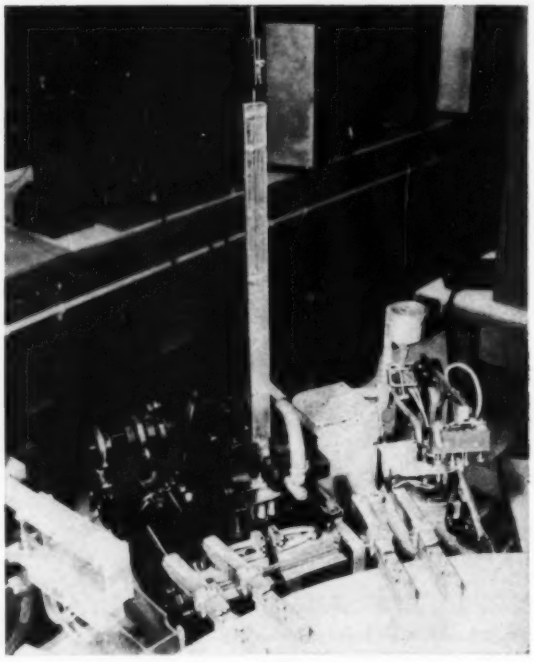


Fig. 7—In this view of the fifth and sixth stations, the index table has been jogged out of position to afford a clearer view of the work stations. On the right is the fifth station. Here, flux is applied to the formed ends of the ribbons (forming was accomplished in the fourth station). At the sixth station (left) NPN germanium bars are fed from the vertical magazine, positioned between the formed ribbon ends, and soldered to the leads by applying heat to the ribbons. When this operation was done manually, small squares of solder were individually placed between the ends of the bar and the formed ribbons. This was considered impractical for mechanized operations, and the idea of preapplying solder spots to the ribbon was adopted.

bly is then indexed to the second station where the three lead wires are trimmed to size. At the third station a Kovar ribbon is fed from a spool, formed on the end, welded to one of the lead wires, and cut off from the spool. The header is reseated at the fourth station to ensure that it is properly aligned for subsequent operations. The fifth station of the machine is an idle position.

When a suitable bar-ribbon subassembly has been tested on the 16-station table, a discretionary control circuit causes the header table to index a prepared header into the sixth station which is adjacent to the fifteenth station of the bar-ribbon table, *Fig.* 10. At this station, the header fixture slides forward, aligning the two bar lead wires directly beneath the bar-ribbon subassembly, and two spot welds are applied. The transistor assembly is then retracted to the header table and is indexed to the seventh station, where the excess ribbon leads on the germanium bar are trimmed. At the eighth station, *Fig.* 11, the assembly is removed from the fixture by means of a magnetic pick-up and transferred onto a track which is used for transporting the units to a subsequent bonding operation. This operation, performed on another machine, welds a flattened 0.002-inch diameter gold wire to the 0.001-inch P-region of the NPN bar and then solders the other end of the gold wire to the solder-clad Kovar ribbon which was installed at the third station of the header table.

▶ Station Drive Units

In addition to the drive units integral with the clutch actuated index tables, there is a drive unit

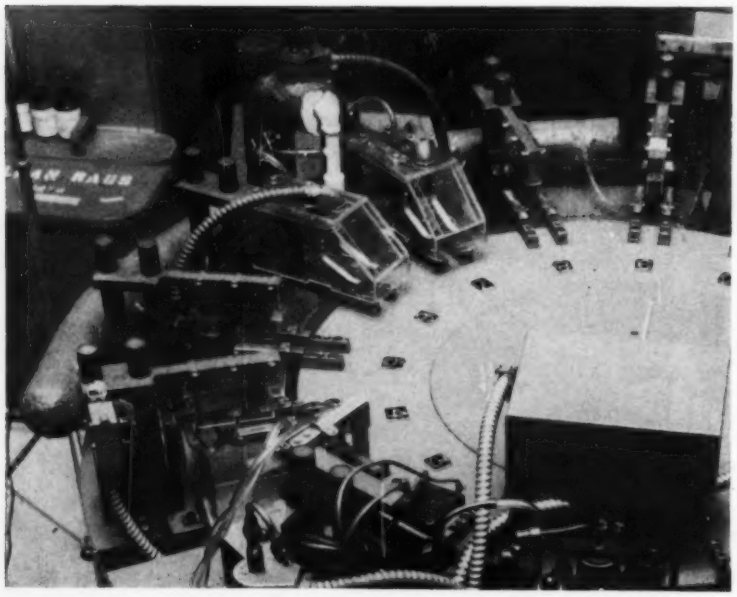


Fig. 8—In this general view of the bar-ribbon table, the rinse and etching stations can be seen. Starting at the top right at the seventh station and going counter-clockwise are two rinse stations, two electrolytic etching stations, and two after-etching rinse stations. These stations are followed by an air drying station and a subassembly test station which appear at the bottom of the picture.

associated with the work stations of each table. The majority of the work stations require a multiplicity of movements and, therefore, have their own camshafts and actuating mechanisms. Other stations such as the blank, rinse, etch, and drying stations, require only vertical motions. These are operated from face cams mounted underneath the work stations, *Fig.* 12. All of the work stations are mounted on stationary brackets around the periphery of the index tables. The drive is transmitted to these stations through two endless roller chains, each mounted horizontally beneath the table and engaging drive sprockets on all of the work stations associated with its respective worktable.

The work cycle and table indexing functions are integrally controlled by a master sequential timer which is located in the control cabinet. This master timer drives several slave timers which are used to trigger various air cylinders and solenoid valves, as well as energize the safety interlock system when desired. In addition, the control cabinet houses the necessary constant current power supplies for electrolytic etching, the power supplies for the soldering operations, three separate capacitor discharge welding circuits along with the test circuit and the controls for the safety interlock system for the entire machine. Auxiliary equipment associated with this machine includes air driers and water deionizing units as well as the pressurized supply tank for the potassium hydroxide etching solution.

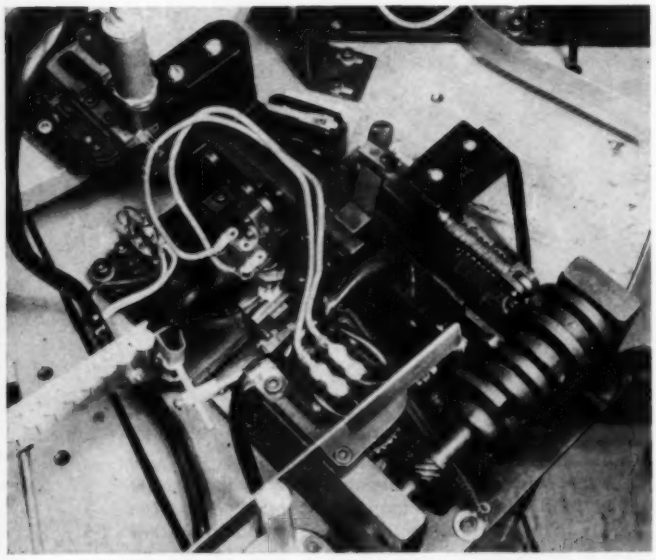


Fig. 9—This view shows the first or loading station of the 8-station header table. A gating mechanism releases each header base assembly into a locating nest where it is picked up by a magnetic transfer mechanism. The assembly is then rotated 90 degrees and inserted in the clamping fixture of the index table (upper left corner of picture). Above the clamping fixture is a phototransistor which will cause the machine to stop if a unit is not properly loaded.

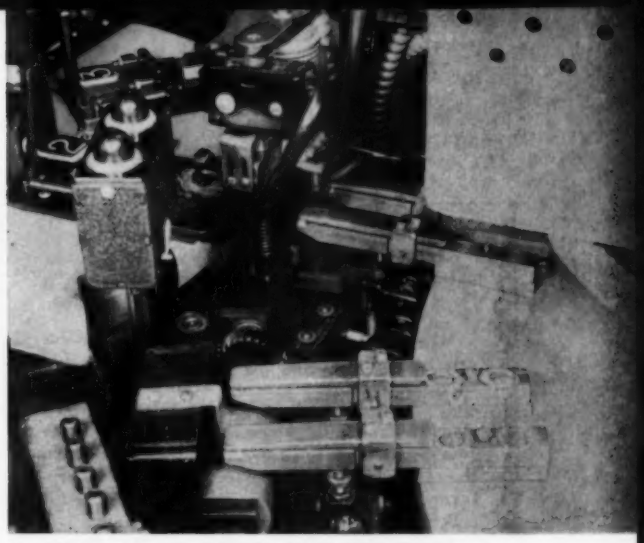


Fig. 10—The common weld station where the bar-ribbon subassembly (right table) and the prepared header (left table) are joined is shown in the upper portion of this picture. In the foreground can be seen the eject station which clears the clamping fixture of bar-ribbon subassemblies that failed to meet the quality test at the fourteenth station of the bar-ribbon table.

▶ Debugging Necessitates Changes

When a large number of operations are performed automatically, unforeseen "bugs" appear. During prove-in, many problems arose. Some were easy to cope with while others were difficult to eliminate. A modification to the ribbon feed station was necessary to provide correct ribbon lengths. Inconsistent solder joints were improved by a series of actions including the effective cleaning of NPN bars, an improved method of fluxing, providing a sufficient and uniform amount of solder, and a heating cycle of proper intensity and duration.

There were numerous difficulties encountered which were associated with the control and mode of operation of the machine. For instance, while operating automatically the machine was completely interlocked from a safety standpoint, but during prove-in the machine was often operated manually. Since machine functions were controlled from both the work stations and the sequential timers in the control cabinet, it was possible, when operating manually, to jog one out of synchronization with the other. This condition was discovered through a minor mishap, but the damage might have been extensive. Most of the control modifications made during prove-in were to provide more versatile manual operations to facilitate prove-in.

Another problem which necessitated a change in plans during the course of prove-in related to the method of solder application to the ribbon leads. The original planning called for a ribbon having a preapplied solder coating. This proved satisfactory insofar as reliable solder joints were concerned but resulted in an intolerable splashing of molten solder on the internal parts of the transistor. Since solder splatter could short the junctions of the NPN bar

THE AUTHOR

RICHARD C. SHAFER, Dept. Chief, Western Electric Co. Inc., studied for his degree in mechanical engineering at Lehigh University. His college education was interrupted by World War II in which he served for three years, attaining the rank of 1st Lieutenant in the Ordnance Dept. After the war, he returned to college and graduated in 1946 with a B.S. degree in mechanical engineering.

Immediately after graduation, Mr. Shafer started his industrial career with Western Electric as a metal piece part engineer at the New York Tube Shop. In 1947, he was transferred to the Allentown Plant in a similar capacity. When initial transistor production was started at Allentown in 1951, he became a development engineer in a group formed to study methods and techniques for the mechanization of transistor processes. During the next five years, the automatic transistor assembly machine described in this article was evolved by this group. In 1956, Mr. Shafer became department chief of the group and held this position until 1957. During the next two years, he was department chief of Machine and Tool Construction. In 1959, Mr. Shafer was transferred to his present position in the Thermistor, Mercury Relay and Switch Dept.

and render the transistor inoperative, a new work station was added to the machine. Two spots of solder are applied to the ribbon leads at the desired locations and the problem of solder splatter was eliminated.

▶ Team Effort

The development and construction of the automatic facility was completed entirely within the Allentown Works, with the exception, of course, of commercial components, which include the index tables, mounting brackets, gears, bearings, air cylinders, etc. It is felt that there are many advantages in developing and building such facilities within our own shops. In the first place, machine development, being so closely interrelated with the assembly and processing operations involved, can have a direct effect on product quality. Anything affecting quality is best controlled at the source. Many of the electronic components manufactured for the Bell System and the processes by which they are made are of such a nature that little or no concept of the tooling requirements are available to those companies specializing in the design and construction of automatic machines. Finally, the experience gained in all aspects of such a development project—engineering, design, scheduling, procurement, construction, prove-in, and maintenance—will better equip the company to meet the challenge of the future.

Manufacturing engineering is responsible for providing the equipment and know-how necessary to meet production schedules at the lowest possible cost commensurate with the quantities and time interval allowed for the introduction of a new device. Mechanization effort at Western Electric is undertaken only after three conditions are fulfilled. The product design must have stabilized, continuing output requirements must be assured, and process capabilities must indicate that a high yield is attainable.

At this stage, the facilities development engineer is given the task of developing the automatic facilities to produce a reliable, low cost device—in this particular case, a grown junction NPN transistor. The facilities development engineer is given free rein over the basic approach to mechanization—the sequence of operations, the type of facilities required, and the responsibility for suggesting processing and design changes which will lend themselves to mechanized production.

While the individual contributions of the facilities

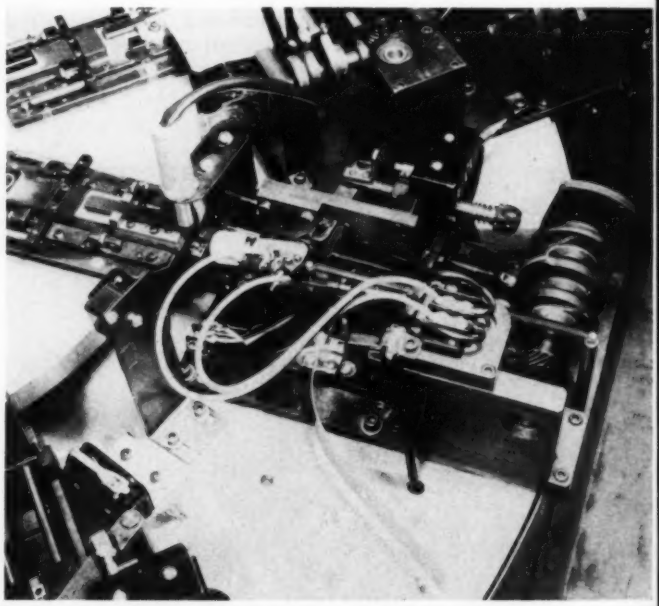


Fig. 11—The completed transistor assembly is removed from the machine at the eighth station of the header table. In this view, the magnetic transfer mechanism is in a horizontal position, and the unloading mechanism is being moved forward on a slide to pick up a transistor from the clamping fixture. After pickup, the slide retracts and rotates the magnetic transfer mechanism 90 degrees so that the transistor can be dropped onto the unolading track in the lower portion of the picture. Above the clamping fixture is a phototransistor which is used as a detection device to ensure that the transistor is actually removed. If the transistor is not properly unloaded, the phototransistor will cause the machine to stop.

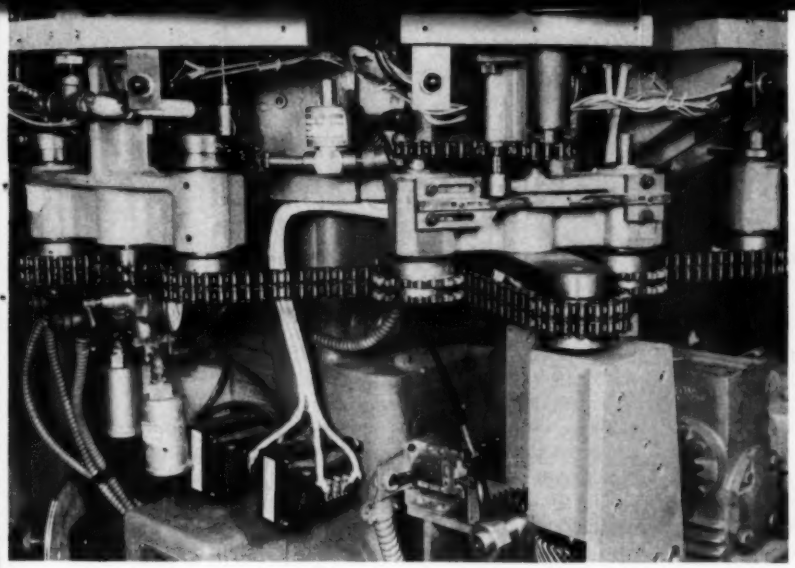


Fig. 12—This view of the table base shows the drive arrangement for five stations on the 16-station bar-ribbon table. The blanking station and the forming station (left) require only vertical motions which are provided by the two face cams. The flux station and the station to feed and solder bars (center) have their own camshafts and actuating mechanisms above the table. Power to operate these devices is provided by the single vertical jack shaft driven by the small single chain. The first rinse station (far right) requires vertical motion and is actuated by a face cam and follower rod. Each of the 16 stations is driven by a sprocket take-off from the main endless chain shown across the center of the picture. In the lower right corner is a gear reducer which drives the main chain through a single revolution timing clutch.

development engineer are easily recognized, his job becomes one of co-ordinating the efforts of a large number of specialists. For instance, the product engineer was consulted regarding his experience gained on the manually operated production line. Tool and machine designers contributed from their particular experience to the mechanical design of the automatic assembly machine. The control cabinet, test circuit and interlock system were the responsibility of the test set engineer. Our chemical engineers were involved with the supply of the ultra high purity deionized water and the etchant solution for electrolytic etching. Plant services required at the assembly machine, such as high pressure and low pressure air, nitrogen, line deionized water, and electricity were the design responsibility of the factory planning engineers.

During construction, toolmakers and test set technicians offered valuable suggestions which were speedily incorporated into the design of this facility to improve operations, and/or reduce costs. Still further refinements were incorporated through the interest displayed by the engineers, technicians, and machine operators assigned to the prove-in chore. Success of the project, as evidenced by the automated assembly of large numbers of reliable, low cost grown junction transistors, is a tribute to the contributions made by the joint efforts of the Bell Laboratories and Western Electric team. However, this unit has produced more than a particular code of semiconductor device. This successful development has produced valuable experience that will prove a great asset in facing problems of automated transistor manufacture that the future is certain to bring.

material characteristics key to automatic molding

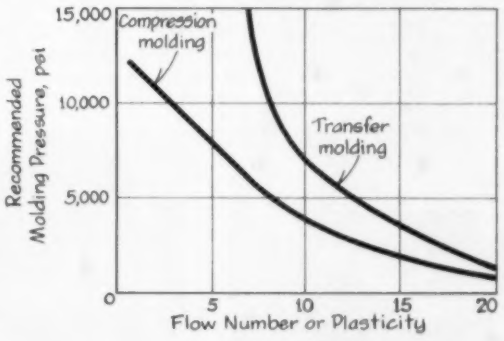
PREDICTABLE flow characteristics are essential in setting up automatic molding methods using fiber-reinforced specialty phenolic and diallyl-phthalate plastics. However, these characteristics are difficult to determine by standard procedures. For example, the fibrous structure of the materials introduces variables that cannot be accurately accounted for in a standard ASTM Cup Flow test.

One manufacturer of specialty phenolics, Rogers Corp., resolved the problem by devising a series of control tests, to insure uniformity of flow from batch to batch. One test permits a precise measurement of flow through an orifice at pressure as low as 100 psi. This makes it possible to predict material performance in transfer and plunger as well as automatic compression-type molding machines.

The accompanying chart illustrates the predictable flow characteristics for a medium impact type of plastic material in terms of recommended molding pressures. The flow numbers range from 1 to 20 and indicate the plasticity of the material. Each batch in a shipment would be marked with its measured flow number so that molding pressures could be easily determined.

In addition to the flow characteristics, other properties of plastic are of key importance to smooth automatic molding operations. These include uniform pellet size, good pourability for feeding automatic preformers and presses, and absence of dust.

Uniform pellet size and a uniform rate of pour are essential to proper loading of mold cavities to prevent overcharging and undercharging. Overcharging produces off-dimension parts having an extremely thick flash which is tough, fibrous, and difficult to remove. Undercharging results in parts that are incompletely formed, or, if formed, have thin sections.



Flow, pellet size, and pourability are thus critical factors in automatic molding. The end results sought are materials whose flow, apparent density, and rate of pour are consistently uniform so the parts emerge from the molds with a small flash easily removed by tumbling.

TELEVISION SYSTEMS MONITOR KILN OPERATIONS

FORMATION of cement clinkers in continuously operating, rotary kilns is carried out efficiently with the aid of instrumentation that automatically controls factors such as fuel input, draft, and material flow. One phase of the process, however, still requires human observation and judgment. That phase involves visual inspection of the interior of the kiln, interpretation of the conditions seen, and corrective action by an operator.

At a Houston plant of Ideal Cement Co., the visual inspection chore has been facilitated by adoption of closed circuit television. Separate systems, developed in co-operation with the Electronics Div., Diamond Power Specialty Corp., serve each of two 450-foot long rotary kilns. Each system includes a camera, a power supply and control unit, and a monitor.

The camera for each kiln is mounted on a platform at the kiln hood, *Fig.* 1. The platform is designed so that the camera can be adjusted for both pan and tilt. Viewing is accomplished through a glass plate which is coated with heat reflecting material. Because of the high temperature at the camera viewing port (nearly 2100 F), both sides of the glass and the entire camera are cooled by air flow from a blower. In the event of blower failure, compressed air will protect the equipment until repairs can be effected.

The power supply and control unit is mounted in the kiln room. The control portion of the unit contains all necessary camera controls including electrical focus and video gain. An automatic gain circuit compensates for variations in light level.

Actual conditions inside each kiln are displayed on a monitor unit in a remote, centralized control room, *Fig.* 2. Utilizing a 17-inch tube, each monitor has controls for contrast, brilliance, focus, and horizontal and vertical synchronization.

With a view of the burning zone of each kiln, a control operator is able to make the necessary process adjustments to ensure the production of uniform clinker. Typical checks possible with the closed circuit television hookup include clinker ring formation and the size of the clinker as it falls. If the clinker is too large, overheating is indicated; if it is too small, the slurry may not have been heated properly in previous drying and calcining zones.

Adoption of closed circuit television in this application has resulted in considerable improvement of over-all plant operation. With monitoring of kiln conditions combined with other control functions, one operator can supervise kiln operation, raw and finish milling, and material storage.

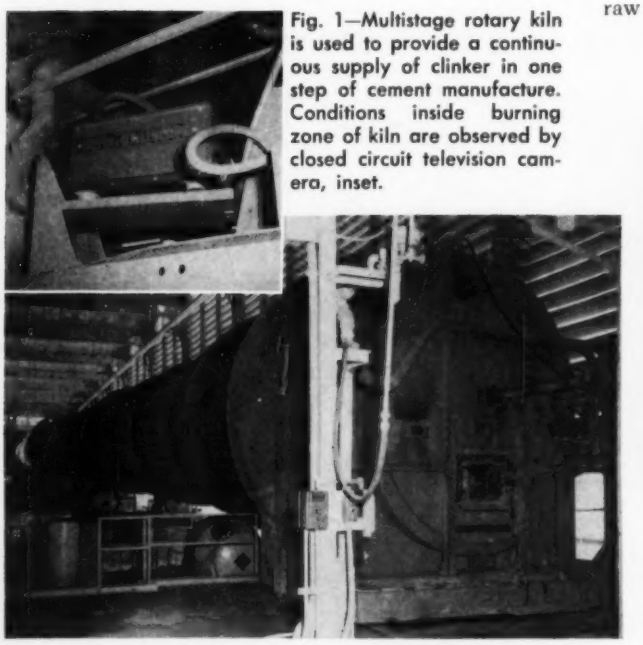


Fig. 1—Multistage rotary kiln is used to provide a continuous supply of clinker in one step of cement manufacture. Conditions inside burning zone of kiln are observed by closed circuit television camera, inset.

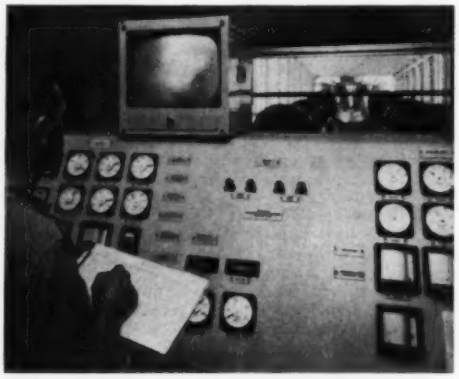


Fig. 2—Operator is shown inspecting monitor image of interior of one of two kilns in background. Closed circuit television systems are used to enable adjustment of flame characteristics for best clinker formation in each kiln.

INFORMATION TRANSFER

By L. B. MITCHELL, Staff Engineer, Industrial Products Div., Automatic Electric Sales Corp., New York, N. Y.

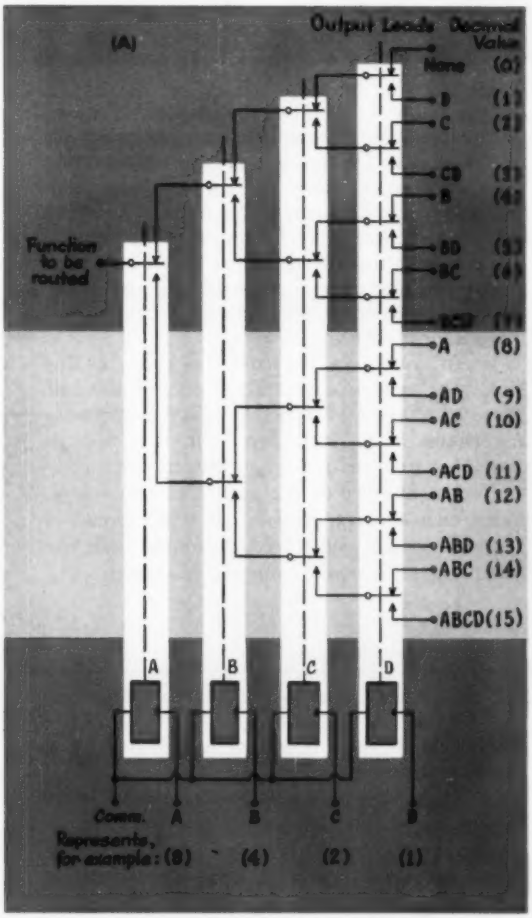
RATIONAL study of the well-developed, complicated circuits utilizing telephone-type relays has led to the identification of various recurring basic circuits in the systems. A corollary to this observation is that a desired complicated circuit can be obtained by interconnecting basic building-block circuits. This then is the reasoning which suggests that what might on the surface appear to be a specialized communication subject is in reality a general subject of interest to all industries.

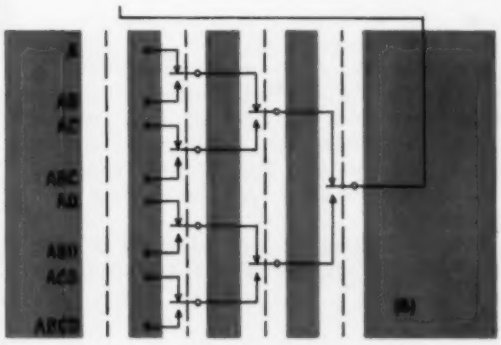
Similar to other devices employing *On-Off* type contacts which can be actuated by a signal, the telephone-type relay is used in straightforward automatic control applications. However, an even greater utility is achieved in applications in which the relay is a switching component of an information handling system. The latter applications are distinguished from control applications in the sense that intelligence is conveyed by such characteristics as "which relays have operated" or "how many relays have operated."

This second article in a series of data sheets on industrial applications of telephone-type relays is concerned with several basic switching circuits that tend to emphasize the information handling capabilities of interconnected relays. The diagrams indicate basic circuits used to achieve unique conditions. With the various spring combinations available in telephone-type relays, it is apparent that additional circuits can be readily integrated with the basic circuits to obtain control or indicating signals.

Transfer Tree

The basic four-relay arrangement, *Fig. A*, illustrates one method of routing a single wire circuit from the input to any one of 16 outputs. As shown by the numbers in parentheses, by means of a circuit such as this, any four-bit code can be translated into a single control signal which can indicate a decimal value or can be the translated function equivalent of the code used.

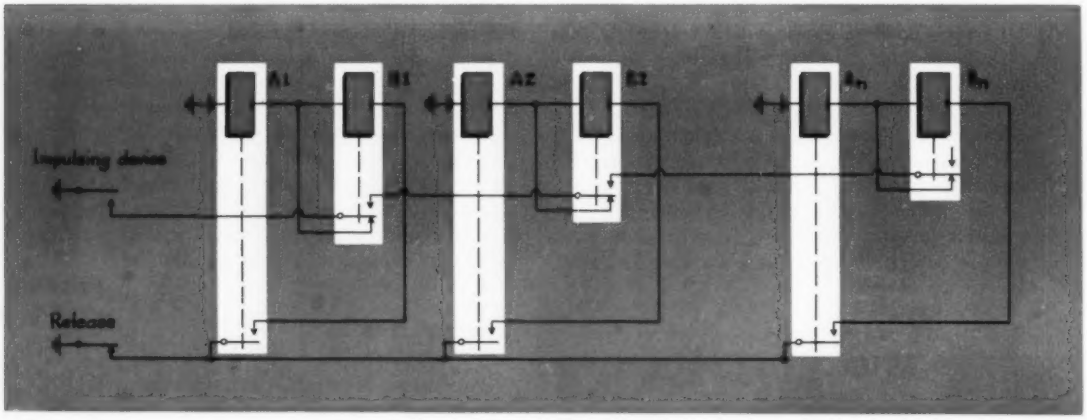




The primary difficulty encountered with a circuit of this type involves the comparative operate times of the four relays. If the relay coils are engineered to provide approximately the same operate time for all four relays (differently powered coils), it is obvious that relay *D* will require much more power than any of the other relays, and this need can in certain circumstances result in excessive contact loads

on the device which controls the relays. If the same coil is used for all four relays, either relay *D* will be very slow, or the contact load on the controlling device will be a problem. In addition to this, the more lightly loaded relays will be vastly overpowered with the possible result that the function input lead may be momentarily connected to any number of the output leads. This can be eliminated by means of a secondary function which activates the input function lead after the four relays have been actuated, resulting in somewhat slower over-all operate time for the circuit.

A refinement which eliminates to some extent the problems inherent in the basic circuit is illustrated by *Fig. B*. The advantage of the refined circuit is that the contact loads of relay *D* in the original example have been distributed between relays *B* and *D*. The total number of contacts used for each circuit is the same but the power requirements of relays *B*, *C*, and *D* have been adjusted to be approximately the same. With this arrangement it is possible to achieve comparatively equal operate times for all four relays without excessive power in any one relay.



Simple Counting Chain

This circuit provides means for counting any number of impulses, using two relays per complete impulse cycle, with simultaneous reset to the zero condition when desired. When operated in this arrangement, all relays in the chain remain operated until the common release circuit is opened.

The impulsing device must remain closed on each impulse for a period of time sufficient to allow operation of the *A* relay in each group of two relays. Similarly, the impulsing device must remain open on each impulse for a period of time sufficient to allow operation of the *B* relay in each group.

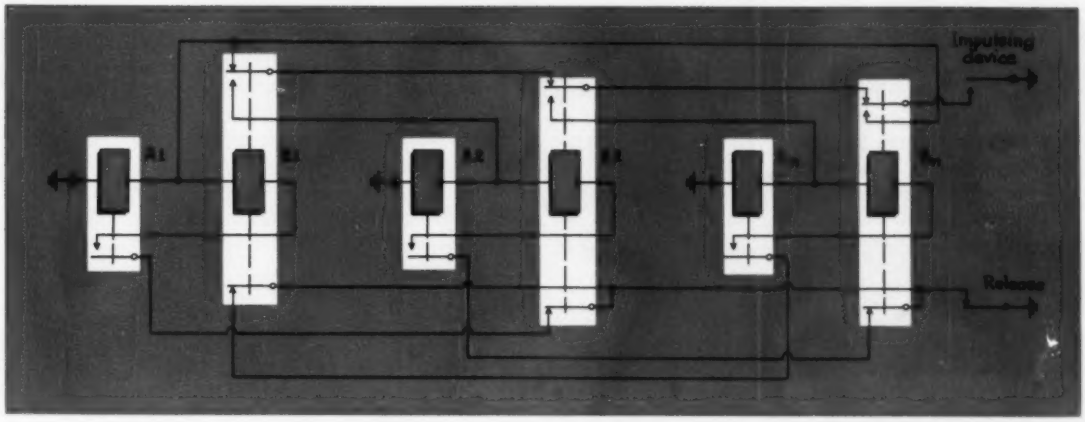
When the impulsing device closes for the first time, relay *A*1 operates. This prepares a circuit for the operation of relay *B*1 when the impulsing device opens. When the pulsing device contacts do open, the short is removed from relay *B*1, and relay *B*1 operates in series with relay *A*1. Operation of relay *B*1 transfers the impulsing circuit to the next group of two relays. Successive impulse cycles operate the *A* and *B* relays in succeeding groups in the manner described for the *A*1 and *B*1 relays.

When release of the counting chain is desired, the release contacts are opened and all operated relays are released. Where long counting chains of this type are built, it is wise to provide a number of release contacts, each controlling a number of the groups of two relays. With such an arrangement, when the circuit is released no one contact is confronted with interrupting an excessive amount of current.

Endless Counting Chain

This circuit can be utilized where a "ring" or endless counting circuit is desired. In use, the operation of each successive group of two relays on each successive impulse causes the group of two relays immediately behind to be released. A reset to the zero condition is provided by a common release circuit.

On each closure, the impulsing device must remain closed for a period of time sufficient to effect operation of the *A* relay involved in the particular pulse. Similarly, when the impulsing device contacts are open, they must remain



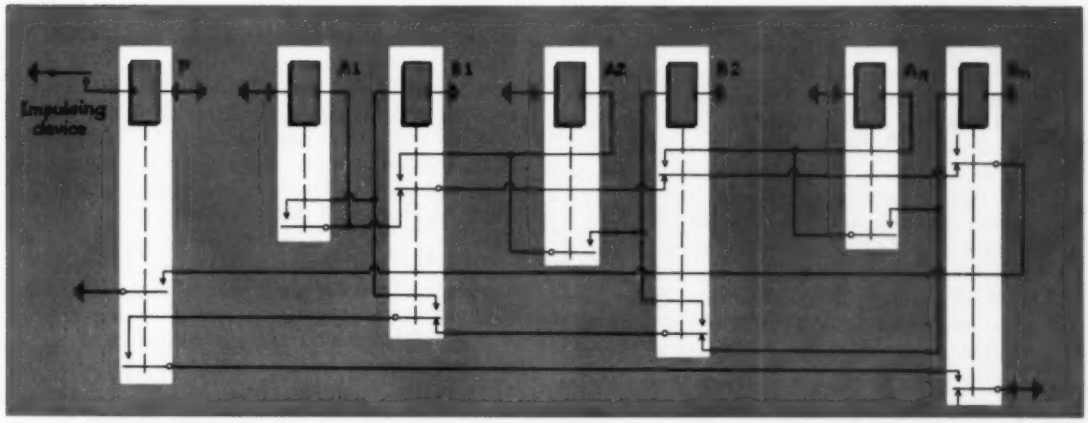
open for a period of time sufficient to allow complete operation of the *B* relay involved.

When the impulsing device closes on the first impulse, a circuit is closed to relay *A*1. Relay *A*1 operates and prepares a circuit for relay *B*1 which, at this time, is shorted by the impulsing device contacts. When the impulsing device opens, relay *B*1 operates in series with relay *A*1 and transfers the impulsing device circuit to relay *A*2. The next operation of the impulsing device will cause relay *A*2 to operate in the manner described for relay *A*1; when the impulsing device opens, *B*2 will operate in series with relay *A*2. Operation of relay *B*2 opens the locking circuit for relays *A*1 and *B*1, causing their release. Successive operations of the impulsing device will cause succeeding groups of *A* and *B* relays to operate, releasing the group immediately behind.

When the final group of two relays (*An* & *Bn*) in the "ring" is operated, relay *Bn*, in addition to opening the locking circuit for the pair of relays immediately behind, also transfers the impulsing contacts back to relays *A*1 and *B*1. The next impulse causes relays *A*1 and *B*1 to operate and effect the release of *An* and *Bn*.

Opening of the release contacts will release whatever pair of relays, if any, is operated and reset the circuit such that the next impulse generated will effect movement of relays *A*1 and *B*1.

A "ring" circuit such as this can be used as a decade counter counting 0 through 9 repeatedly and, with appropriate additional circuitry, carry an impulse into a similar successive decade circuit each time the ninth pair of relays is operated and the tenth impulse is received. In this manner one is carried over into the tens decade circuit and the units decade circuit is reset to zero.



Count Up, Count Down Chain

The illustrated counting chain circuit counts in a manner similar to that explained for the simple counting chain. The difference in this arrangement is that when the final pair of relays (*An* & *Bn*) in the counting chain has been operated and the equipment stands with all counting relays energized, the circuit is now shifted in a manner such that successive impulses received from the remote source will cause the chain to step downward in a two-step manner commencing with relays *A*1 and *B*1. When the final pair of relays has been stepped down, the

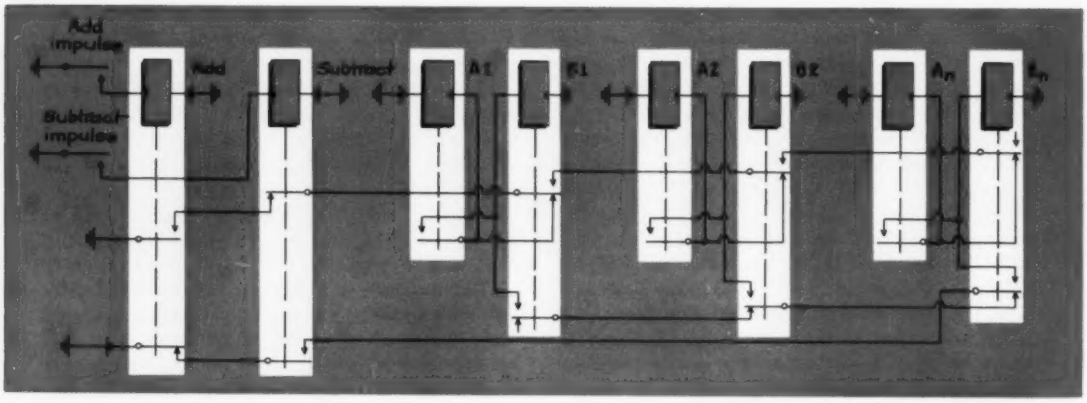
circuit again is arranged so that successive impulses received from the remote impulsing device will cause the relay equipment to step upward.

The impulsing device and associated relay *P* must on each closed period remain closed for a sufficient period of time to allow operation of the *A* relay involved. Similarly, the impulsing device and relay *P* must remain open on each complete impulse for a period of time sufficient to allow complete operation of the *B* relay involved.

The first time relay *P* operates, following the impulsing device, a circuit is closed to relay *A*1. Relay *A*1 operates and prepares a circuit for relay *B*1. When relay *P* restores following the impulsing device, relay *B*1 operates and transfers the impulsing circuit from relay *P* to the next relay, etc. Successive impulses from relay *P* will cause successive groups of two relays to operate until relays *An* & *Bn* are operated.

When relay *Bn* operates, it opens the impulsing circuit from relay *P* which has been used to effect operation of the groups of two relays. Similarly, a new and opposite impulsing potential is provided for use by the other pair of contacts on relay *P*.

The next operation of relay *P* will cause relay *A*1 to be shorted and relay *B*1 to be held in the operated position. Relay *A*1 will restore and, following the restoration of relay *P*, relay *B*1 will restore and extend the restoring potential to the next group of two relays. Successive operations of relay *P* will cause the successive restoration of first the *A* and then the *B* relay in each group. When relays *An* and *Bn* have been restored in this manner, the impulsing potentials at the contacts of relay *P* are again reversed, allowing the circuit to count upward.



Add and Subtract Counting Chain

This relay counting chain is arranged to count up or down as successive add or subtract impulses are received from remote points. The circuit is arranged in a manner such that subtract impulses are not acknowledged until such time as add impulses have, in fact, been received.

The remote add and subtract impulse devices and their associated relays must in every case remain closed on any one impulse for a period of time sufficient to cause operation of the *A* relay involved in a group of two counting relays; similarly, the circuit must remain open on a given impulse cycle for a period of time sufficient to allow operation of the *B* relay (or in the case of subtraction, restoration of the *A* and *B* relays).

Operation of the *Add* relay as a result of an add impulse will close the circuit to relay *A*1. Relay *A*1 operates and prepares the circuit for relay *B*1. When the *Add* relay restores, the short is removed from relay *B*1 and that relay operates in series with relay *A*1. Relay *B*1 transfers the add impulse circuit forward to the *A*2 relay. Successive impulses generated by the *Add* impulsing device and associated *Add* relay will cause successive groups of two relays to be operated.

Subtract impulses received (after add impulses have been registered) will cause the relay *A* of the most recently operated pair to be restored during that period of time that the *Subtract* relay is operated. Relay *B* of the pair involved will remain operated until the *Subtract* relay restores. When the *Subtract* relay restores the *B* relay involved will restore and the counting chain will have had one count subtracted.

The *Add* and *Subtract* relays are interconnected in a manner such that if the *Add* and *Subtract* impulsing devices generate impulses of equal length, simultaneous reception of an add and subtract impulse will cause no movement in the counting chain because the two relays mutually inhibit operation of the opposite action. However, one signal might lead the other by a period of time equal to the operate time (or release) of a particular relay. The design of the circuit assumes that the trailing signal will also remain closed long enough following removal of the leading signal to re-establish the status quo existing before the two closely spaced signals were received.

7½ hp Ajusto-Spede Drive

Common motor-drive housing for units up to 7½ hp saves space — can be foot- or flange-mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

The Louis Allis AJUSTO-SPEDE® drive is more compact, precise, and trouble-free

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor.

®Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.

The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 463 E. Stewart St. Milwaukee 1, Wis.

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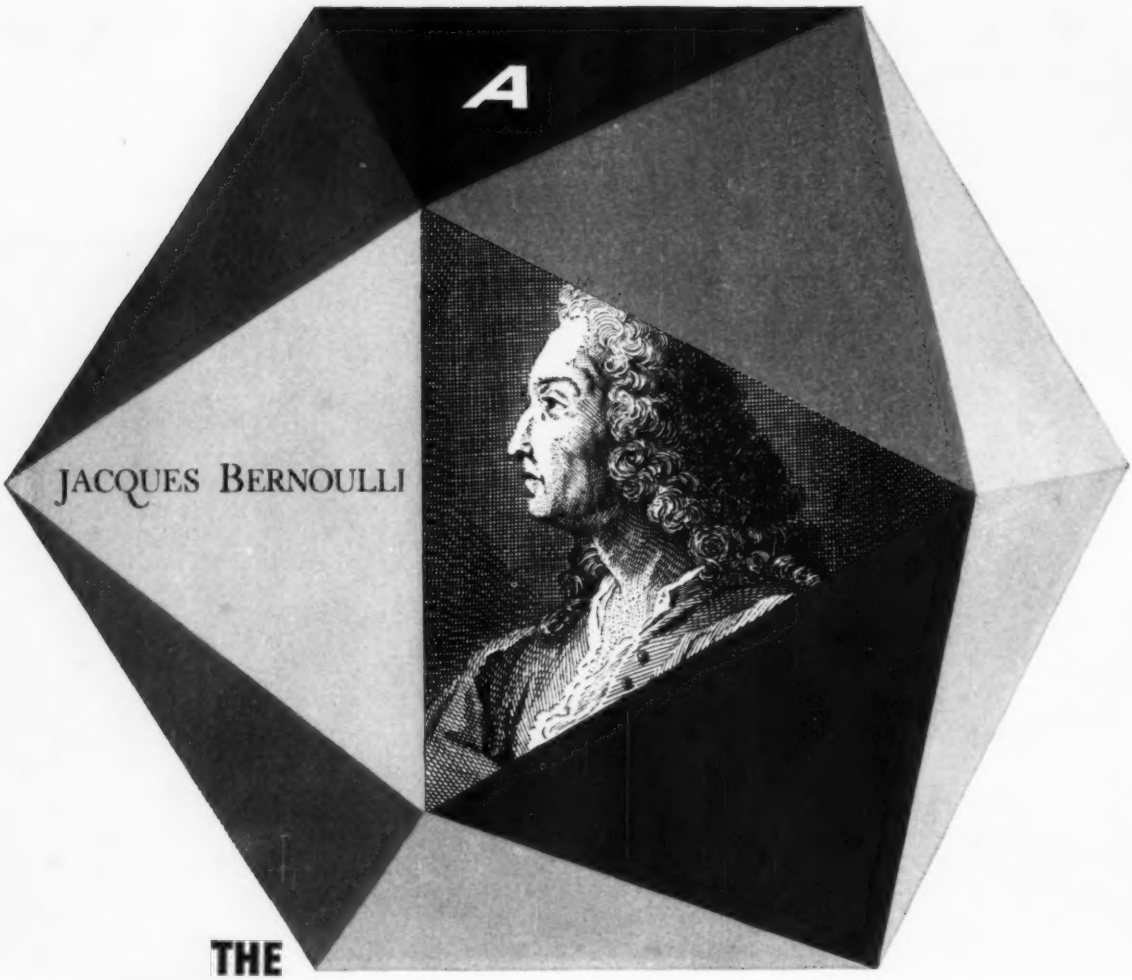
LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

AS-109



THE WIZARD OF ODDS

He solved a telephone traffic problem two centuries ago

Jacques Bernoulli, the great Swiss mathematician, pondered a question early in the 18th century. Can you mathematically predict what will happen when events of chance take place, as in throwing dice?

His answer was the classical Bernoulli binomial distribution—a basic formula in the mathematics of probability (published in 1713). The laws of probability say, for instance, that if you roll 150 icosahedrons (the 20-faced solid shown above), 15 or more of them will come to rest with side "A" on top only about once in a hundred times.

Identical laws of probability govern the calls coming into your local Bell Telephone exchange. Suppose you are one of a group of 150 telephone subscribers, each of whom makes a three-minute call during the busiest hour of the day. Since three minutes is one-twentieth of an hour, the probability that you or any other subscriber will be busy is 1 in 20, the same as the probability that side "A" of an icosahedron will be on top. The odds against 15 or more of you talking at once are again about 100 to 1. Thus it would be extravagant to supply your group with 150 trunk circuits when 15 are sufficient for good service.

Telephone engineers discovered at the turn of the century that telephone users obey Bernoulli's formula. At Bell Telephone Laboratories, mathematicians have developed the mathematics of probability into a tool of tremendous economic value. All over the Bell System, the mathematical approach helps provide the world's finest telephone service using the least possible equipment. The achievements of these mathematicians again illustrate how Bell Laboratories works to improve your telephone service.

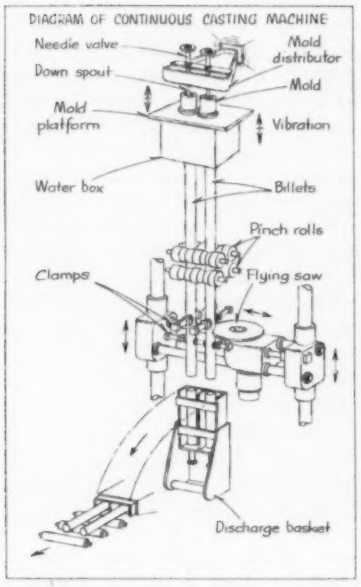
BELL TELEPHONE LABORATORIES

World center of communications research and development

AUTOMATION

new equipment

Machines and plant equipment for more automatic operations,
For detailed information and literature, use card on page 19.

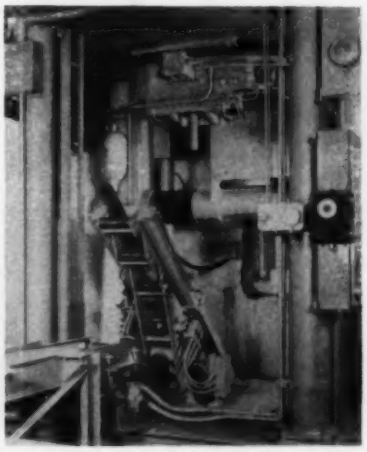


Copper billet and slab casting machine receives molten metal from a holding furnace and discharges strands of round billets, square bars, or rectangular slabs cut into lengths. Machine uses two operating floor levels. The mold platform is located on the upper floor; the pinch rolls and cutoff saw on the lower floor.

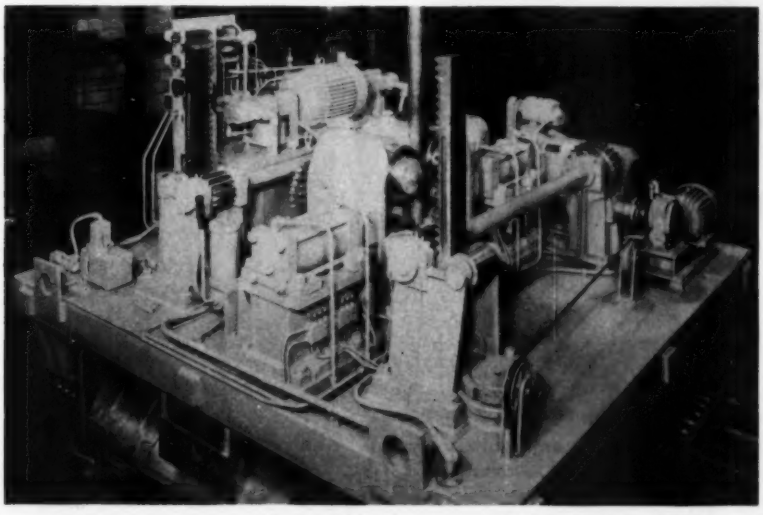
Continuous Casting Machine for Copper Billets

CONTINUOUS casting machine can handle copper in all forms, is also suitable for casting brasses, bronzes, aluminum, and magnesium alloys. The shapes produced include round piercing and extrusion billets, square wire bars, and rectangular slabs. Production capacity of the machine ranges from 3 tons per hour for double-strand casting of 3-inch diameter billets to 10 tons per hour for single-strand casting of 5½ by 33-inch slabs. The machine, which is designed by **Loma Machine Co. Inc.**, 114 E. 32nd St., New York 16, N. Y., handles copper in forms from phosphor de-oxidized and oxygen-free to fire refined and tough pitch.

In operation, the machine is fed with liquid metal from either an arc or induction melting furnace followed by an induction holding furnace. The molten copper at a temperature of 2150 F then flows through a special refractory-lined distributor equipped with down spouts extending into the molds. The rate of flow of the metal through the spouts is controlled by the operator with needle valves. The molds, which are mounted at the top of the casting machine, are of copper construction, and the water jackets have an internal baffle design that increases the heat removal capacity. The cooling water first flows through the mold jackets and emerges from an adjustable slot at the mold bottom to strike on the solidified metal surface in direct



After being cut off on the fly by the circular saw, a cut billet is removed by the tilting discharge basket.



Cast bar coming down from mold platform is withdrawn from mold by pinch rolls shown.

spray form. The spray water collects in a water box mounted below the molds and is recirculated.

To prevent sticking of the cast copper to the mold and assure a smooth surface, the entire mold assembly is oscillated vertically by a reciprocating mechanism. The metal strands are withdrawn from the molds by a double set of 9-inch diameter pinch rolls made of stainless steel. Clamping pressure is applied to the pinch rolls by opposed hydraulic cylinders. The pinch rolls are driven through reduction gearing by a 5 hp dc motor to obtain infinitely variable casting speeds up to 60 ipm. Below the withdrawing rolls and mounted on a vertically traveling carriage is a flying circular cutoff saw. The saw uses a 36-inch diameter segmental blade driven by a 40 hp motor. The cut billets or slabs are received in the discharge basket which is tilted automatically by a pneumatic cylinder through 90 degrees. When the basket reaches its horizontal position, the castings are ejected onto a roller conveyor by air cylinder action. Here, an air-operated stamping device applies an identification mark to one end of each casting.

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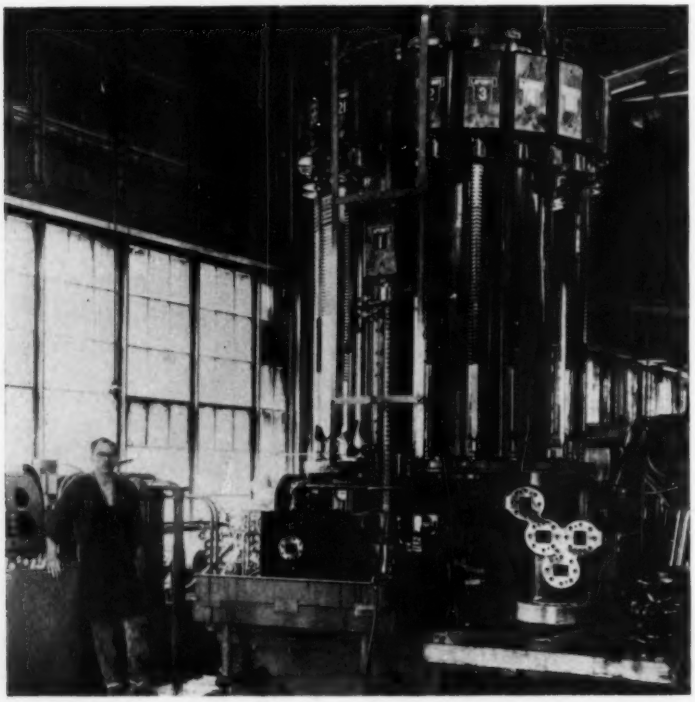

Twenty-one station vertical broaching machine is adaptable to any application which requires multiple internal broaching.

Programmable Turret Broaching Machine

Vertical broaching machine features a turret to hold 21 broaches and a design to apply dead center pull on the broach. The turret is 6 feet in diameter, has 21 stations for storing the 80-inch long broaches. Each broach is held by its own holder. The turret, which is automatically lubricated by a circulating pump system, has a variable speed hydraulic motor drive that is preset by the operator. The broach in the machine is pulled dead in line with the cylinder by the pull head attached to the end of the piston rod. The broach is securely held at the top and bottom during normal pull and intermittent peak pull of 85 tons, with a 78-inch stroke. It has an auxiliary hydraulic system for automatic operation of the turret, the table, and the broach-carrying mechanism.

In one application the unit broaches 6-way oil field gate valves using ten different broaches per hole and finishing a hole in 15 minutes. Allowing an additional 30 minutes for handling, the total floor-to-floor time to broach the complete valve is 2 hours. In operation, the pushbutton panel allows the operator to select the finished hole size and then set the machine for automatic cycling with the required sequence of broaches. Broaches can also be automatically rotated to transpose rectangular axes. For instance, with the gate valve, two of the rectangular broached holes have their long axes in one direction and four have their long axes perpendicular to that direction. When the *Broach Position Selector Switch* is set, the broaches will then automatically rotate into position to broach a particular hole with its long axis in one direction and then remain in normal position to broach the next hole with its long axis in the perpendicular direction. The cutting speed is variable, to a maximum of 25 fpm. A selector switch permits automatic selection of either of two predetermined broaching speeds, with a return speed of 50 fpm. Normal roughing speed is 20 fpm; finishing speed is 6 fpm which is automatically cut in by any of the finishing broaches in the turret. **Lapointe Machine Tool Co.**, Hudson, Mass.

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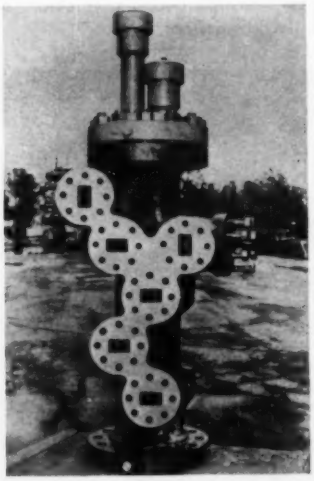
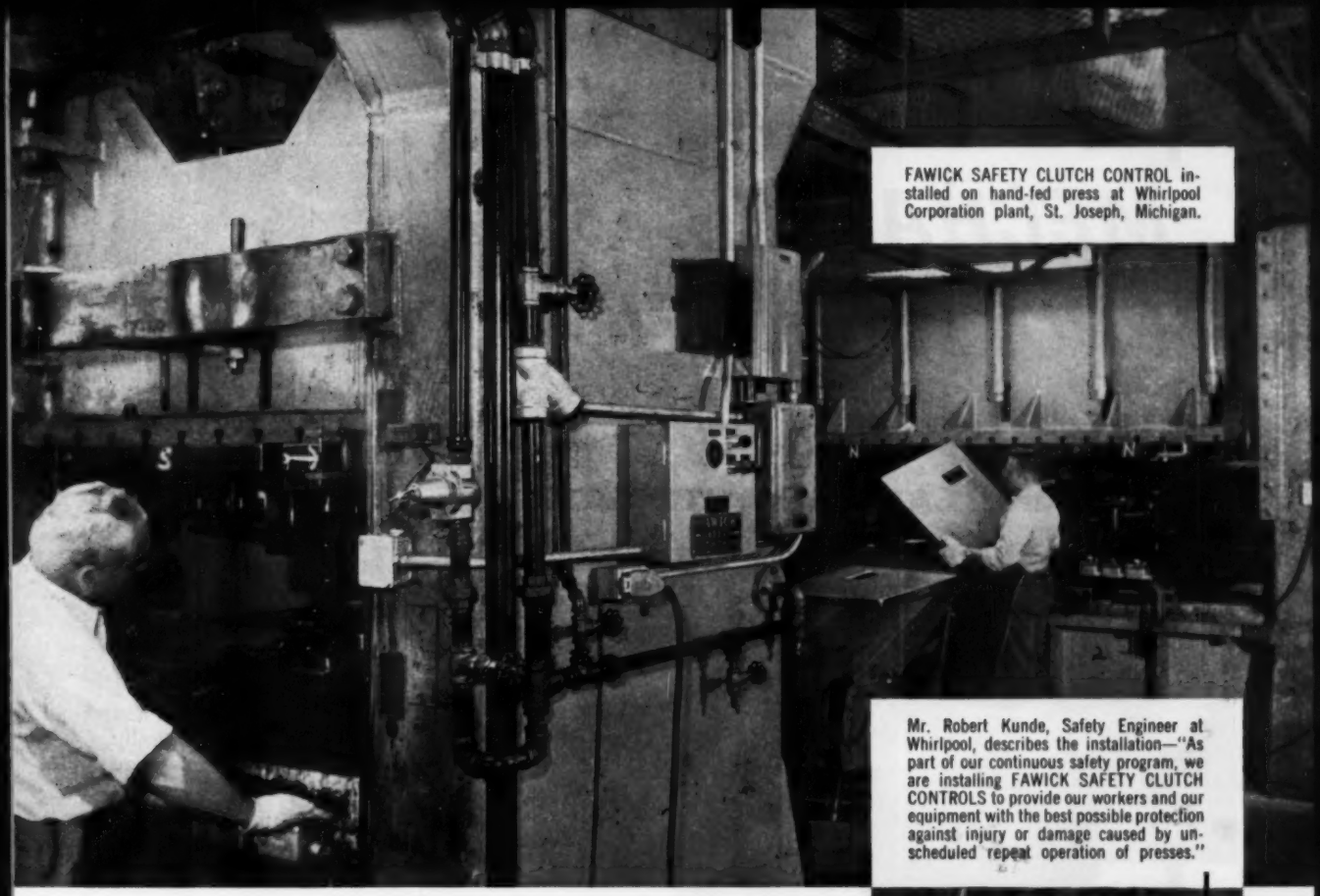


Six-way oil field valve shows typical application of turret broaching machine. This valve is broached at the rate of 15 minutes per hole, using 10 broaches per hole, and broaching all 6 holes in 90 minutes.



FAWICK SAFETY CLUTCH CONTROL installed on hand-fed press at Whirlpool Corporation plant, St. Joseph, Michigan.

Mr. Robert Kunde, Safety Engineer at Whirlpool, describes the installation—"As part of our continuous safety program, we are installing FAWICK SAFETY CLUTCH CONTROLS to provide our workers and our equipment with the best possible protection against injury or damage caused by unscheduled repeat operation of presses."

another Fawick First!

. . . the new "fail-safe" press and automation control

Press owners and operators alike are very enthusiastic about the new FAWICK Safety Clutch Controls (Andrus-Coon System). This outstanding development prevents "unscheduled" repeats in press operation, with a "fail-safe" system that eliminates possibility of component operation failure.

The FAWICK Safety Control utilizes a dual system, with two completely independent sets of controls and all systems and circuits so established, either before or during the operating cycle, that two complete and separate control systems are functioning at the time the "automatic stop" (at the top of the stroke) is required. The mathematical law of probability of simultaneous failure of two similar (or even dissimilar) devices in this system has been calculated conservatively at one (1) in 110,000,000,000 cycles. This great safety advancement is available for installation on new equipment or that being re-newed or overhauled.

For complete details on the FAWICK Safety Clutch Control call or write your nearest FAWICK representative or the Home Office, Cleveland, Ohio.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX
INDUSTRIAL CLUTCHES AND BRAKES

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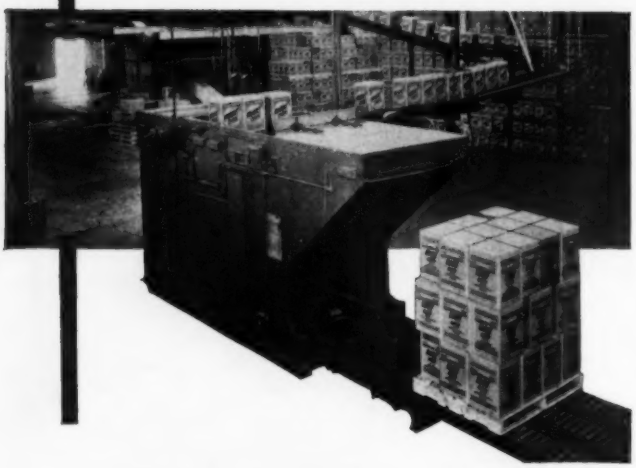
MECHANIZE... PROFIT-WISE!

...with a LAMSON AUTOMATIC PALLET LOADER



Palletizes cartons, cases, rigid bags quickly, economically

Referred to as the "perfect link between packaging and warehousing," the LAMSON AUTOMATIC PALLET LOADER is acclaimed as a huge, money saver by leading producers of package products.

Man hours per pallet load are cut. Considerable saving occurs in the reduction of damage or breakage to cartons. Valuable men are freed for other important duties.

These reductions have been more than enough to amortize the entire cost of the LAMSON AUTOMATIC PALLET LOADER.

The introduction of the Automatic Pallet Loader was another LAMSON first in the materials handling field. A result of the ceaseless engineering vitality of LAMSON men firmly based upon 75 years of experience.

Why not bring your materials handling problems to the leaders in the field? Write LAMSON today for the name of your nearest Field Engineer. Or, simply clip this advertisement to your letterhead and mail to:

LAMSON

PIONEERS *the Conquest* OF INNER SPACE

LAMSON CORPORATION

208 Lamson Street, Syracuse 1, New York

PLANTS IN SYRACUSE AND SAN FRANCISCO • OFFICES IN ALL PRINCIPAL CITIES

Manufacturers of Airtube® (Pneumatic Tube Systems) • Integrated Conveying Systems • Pallet Loaders • Selective Vertical Conveyors • Bookveyors® Clinical • Trayveyors® • Food Service Systems • Blowers and Exhausters • Exidust® Central Vacuum Cleaning Systems • Dryset® Air Vacuum Systems

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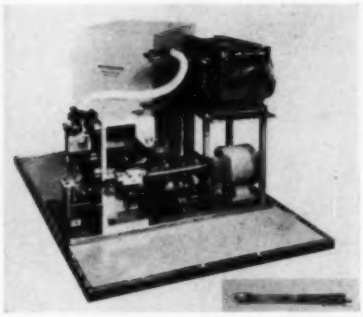

Ribbon Contact Welder

Model C-455 can automatically feed continuous lengths of contact strip from a reel to an adjustable, predetermined length by means of an adjustable feeding device. Machine can handle material 0.047-inch thick by 0.125-inch wide by 0.125-inch long. The contact material is cut off to length and the contacts are then automatically carried to a nested electrode where they are placed so the contact finger can be positioned over the contact. The operator engages the clutch which brings the electrodes down to weld the contact to the contact finger. The welded part is automatically raised to permit the succeeding contact to be fed into the nesting electrode for the welding of the next part. The welded assembly is ejected and a new contact finger placed over its contact for welding. Production rate is 2200 contacts per hour. **Federal Tool Engineering Co.**, 1384 Pompton Ave., Cedar Grove, N. J.

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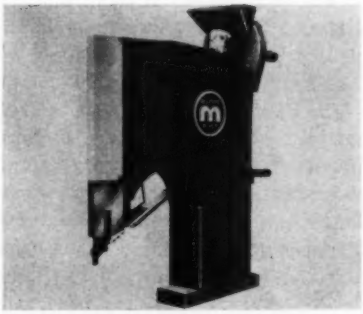
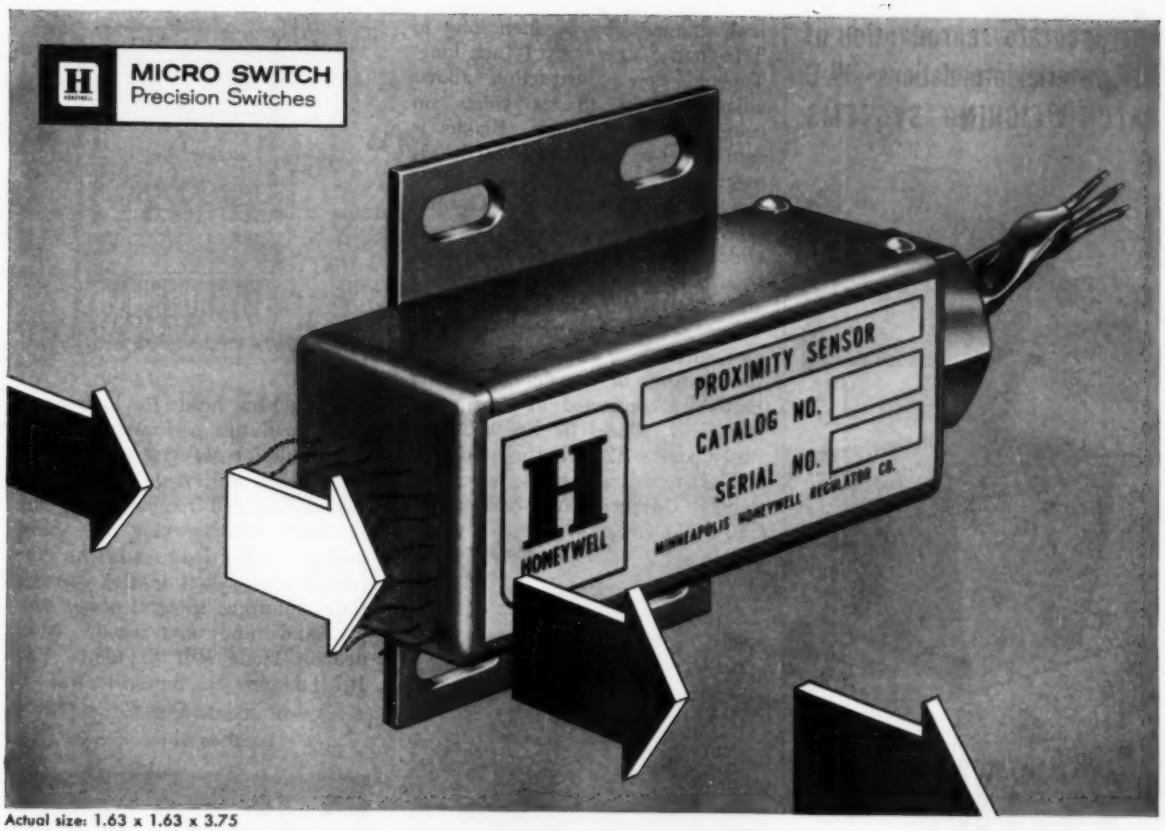


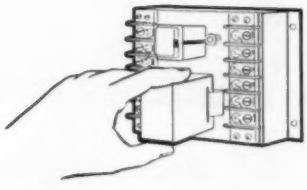
Pneumatic Riveter

Riveter head, especially suited for mutihead installations, can handle semitubular, full tubular, or bifurcated rivets ranging from 1/8-

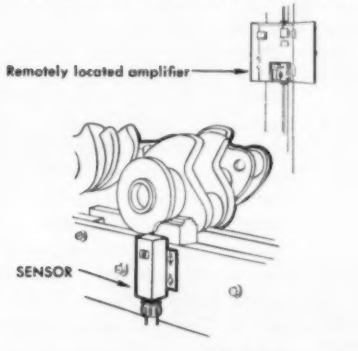


Actual size: 1.63 x 1.63 x 3.75

BUSY SWITCH
without a moving part!



Plug-in relay in amplifier cuts downtime.



Amplifier is separate, may be remotely located.

Honeywell Proximity Switch opens new ideas for up-dating machines and methods

This amazing new switch solves many automation problems that previously could not be tackled. It detects metal parts that pass within ½" of the sensor—over 600 operations a minute—without ever touching them. Perfect answer where rough parts or corrosive atmosphere may damage a mechanical switch or where the delicate finish of a product might be marred by physical contact.

The Honeywell sensor has no moving parts to wear out, need never be replaced! It has a rugged stainless steel face. The sensing unit is sealed against cutting oils, filings, humidity, sand and dust, can operate submerged if necessary.

A Proximity Switch can be your answer to difficult switch problems, but be sure it is a product of Honeywell research. Contact the nearby MICRO SWITCH branch office and ask for Data Sheet No. 163.

MICRO SWITCH, FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

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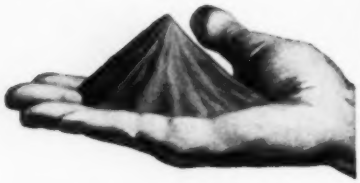
For accurate reproduction of bulk material formulations—W-C BATCH-WEIGHING SYSTEMS



In any batching operation—from simple dump-and-fill weighing to multi-ingredient ratioing — W-C Batch-Weighing Systems provide the reliably accurate net-weight control essential to consistent product uniformity.

Chief reason for this is the W-C Pneumatic Weight Transmitter. A rugged yet sensitive force-balance unit, it is capable of an accuracy of ±0.25% calibrated weight range, with reproducibility better than 1 part in 2000.

Each W-C Batch-Weighing System is designed to job specifications, using pre-engineered, unitized components of *known* performance capabilities. Consequently, you are spared the uncertainties—and costs—of "prototype" engineering . . . yet you realize the very tangible benefits of an application-engineered system built to your requirements.

Typical applications include: Formulating solid rocket fuels, refractories, varnishes, plastics, food products, dry or liquid.

Write for new Bulletin 14

W-C

WEIGHING & CONTROL COMPONENTS, INC.
Div. of CompuDyne Corp.
E. County Line Road • Hatboro 12, Pa.
9.A. 2129

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inch diameter by 1/8 inch long to 3/16-inch diameter by 1 inch long. Tapered nose construction allows adjacent units to set rivets on centers down to 1 inch. Riveter is actuated by pneumatically driven toggle linkage operating on 60 to 150 psi shop air pressure. Cycling speed is governed by the rate at which rivets feed into the jaws. Unit is connected directly to a shop air outlet when used individually. When several heads are grouped on a single base and combined with slide fixtures or transfer tables, the heads are connected to a common manifold. Model 57 has a 3-inch stroke and a 12-inch throat depth. Stroke speed is adjustable to control impact. **Milford Rivet & Machine Co.**, Milford, Conn.

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Code Imprinter

Conveyor and case-sealer attachment places a code imprint on the rear surface of cartons and shipping cases as they travel along a production line. Unit, designated Rolacoder, can imprint any size container from 3 inches high. In operation, the coding head of the attachment automatically moves out of the housing as the container travels by, rolls its imprint across the rear surface, then retracts to its original position, where it remains until the next container reaches the point of coding. **Adolph Gottscho Inc.**, Hillside 5, N. J.

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Tape Handler

Device is available in three styles to handle magnetic tape lengths of 35, 80, or 100 ft. The loop mechanisms feature an isolated tape path under the multitrack record

and playback heads for high precision low-flutter performance. Unit is suitable for use with analog computers and with wave analyzers to examine the full frequency spectrum recorded over varying reel time periods. Other features of the tape handler are: Dual tension sensors, slide mounting, integral power supply, and nine tape speeds. **Minneapolis-Honeywell Regulator Co.**, 10721 Hanna St., Beltsville, Md.

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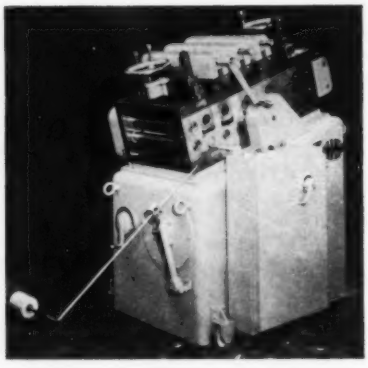

Coil Stock Straightener

Model PDS-16H can handle cold rolled steel, hot rolled steel, brass, copper, and aluminum up to 16 inches in width and up to a maximum of 1/4 inch in thickness. It is used to straighten material in coil form before it is fed into punch presses, press brakes, or other fabricating equipment. The straightener is arranged with a pair of power driven take-in rolls, six straightening rolls, and a pair of power driven take-out rolls. A 5 hp variable speed drive unit provides outputs from 10 to 50 fpm. **U. S. Tool Co. Inc.**, Ampere (East Orange), N. J.

Circle 407 on Page 19

NEW

Gardner-Denver "Airfeedrill"® with "aircheck" feed control

Check these "aircheck" features

- √ Low initial investment . . . simple to maintain . . . economical to use
- √ In-line hose arrangement
- √ High-speed feed with slow break-through for clean holes
- √ Closer center-to-center mounting
- √ Short over-all length
- √ Develops full ⅓ hp

NOW

simple, easy, low-cost automation of many drilling setups

Now it's easy and inexpensive to automate drilling such materials as plastics, wood, aluminum, steel, cast iron and sheet metal. Engineer an automatic drilling setup with new Gardner-Denver "Airfeedrills" with "aircheck" feed control.

These versatile new drills are easily adaptable to almost any drilling setup. You mount them as a drilling unit of two, 20 or more spindles for automatic hole processing. Use one as a stationary drill mounted on an inexpensive fixture. As a portable drill, "Airfeedrill" hangs by its nose to a jig for precision drilling.

See for yourself how quickly and inexpensively you can automate *your* drilling operations . . . see your Gardner-Denver representative or write for Bulletin 92-121.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

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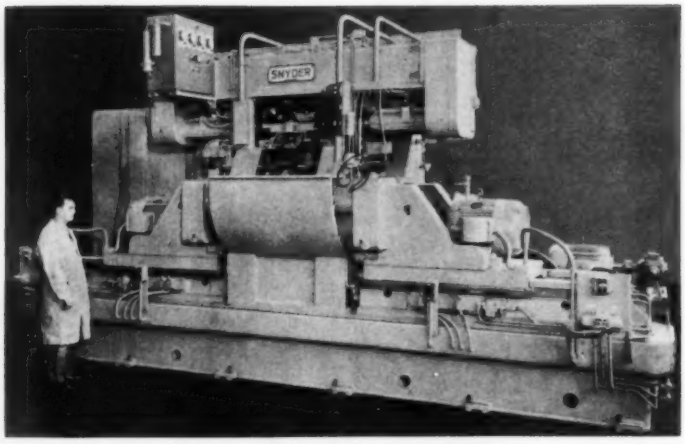

Milling and Threading Machine

Six-station, trunnion type index machine utilizes in-process gaging and thread rolling techniques to finish both ends of forged steel truck steering knuckle control arms at a rate of 144 parts per hour. An index fixture holds two parts in each station, completing two finished parts with each index of the machine. The station operating sequence for the production cycle for each part end consists of: First station, load and unload; second station, spot drill, face and chamfer; third station, rough hollow mill the thread diameter; fourth station, finish hollow mill a diameter adjacent to the thread portion; fifth station, finish hollow mill the thread diameter; and sixth station, gage thread diameter and roll threads.

At the sixth station, an in-process gaging operation is used in connection with the thread rolling cycle. Before the threads are rolled, hydraulic cylinder-operated scissors-type toggle mechanisms cause air snap gages to check the diameters of both ends of both parts. If the diameters of both parts are correct, the thread rolling sequence is initiated. If either part fails to pass the inspection check, the machine is automatically shut down. **Snyder Corp.**, 3400 East Lafayette, Detroit 7, Mich.

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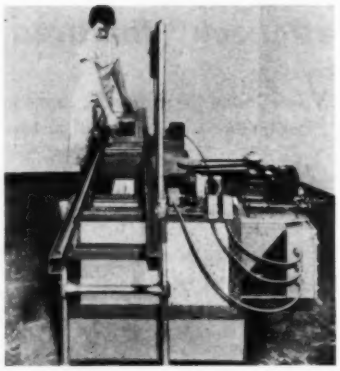
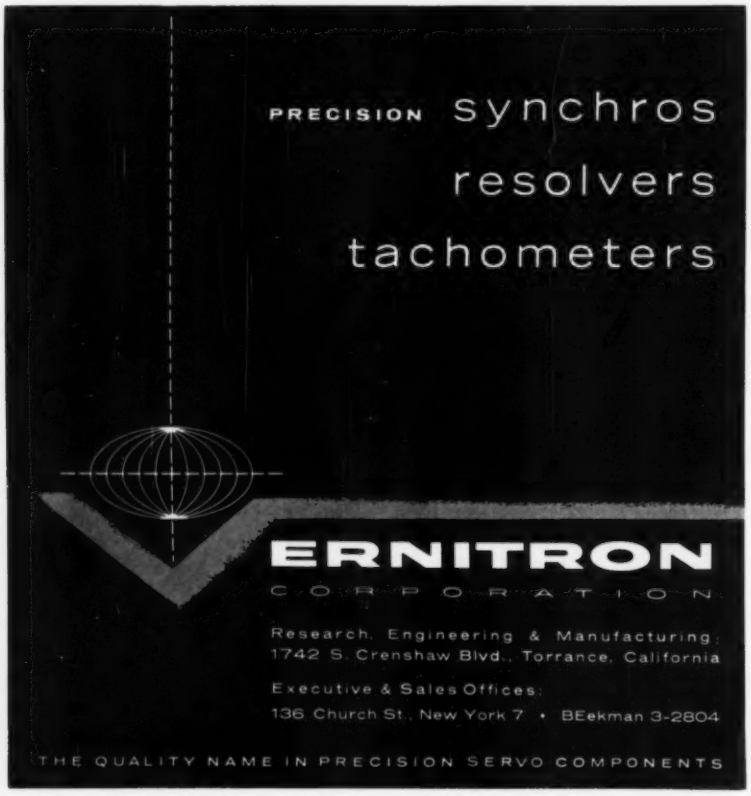


Soldering System

System provides an automatic method of soldering printed circuit boards or other electronic and machine component assemblies up to 9½ inches wide. System consists of a conveyor or transfer mechanism, a fluxing unit, heat bank, and adjustable board carriers. Heart of the system is a Flowsolder machine which brings the molten solder up to the under surface of the assembly. Solder is forced, by means of an impeller pump, through an elongated nozzle so that it forms a standing laminar wave. This wave allows straight-line processing and produces production speeds of up to 15 fpm. The nonturbulent solder wave allows flux gases to escape and the gentle washing action of the constantly moving metal in the wave prevents trapping of gasses or air at the joints. The metal flow also insures uniform soldering temperatures.

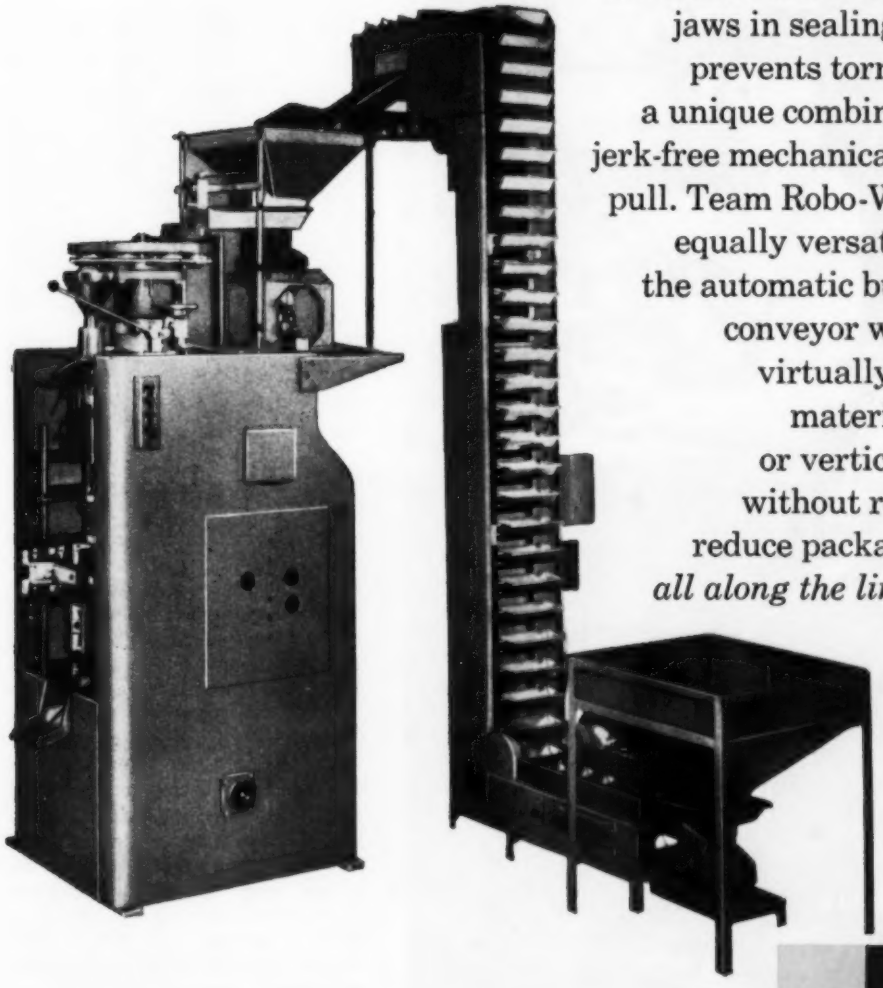
The fluxing unit applies liquid flux to the boards by means of a wave similar to the solder wave. After fluxing, the board travels over the infrared heating unit where the



Circle 694 on Page 19

ROBO-WRAP

Liquids, powders, solids, granules: Robo-Wrap versatility forms, seals and fills up to 120 poly, cello, paper, plastic or laminate pillow packs per minute, with a reject rate that's negligible. New standards of sealing . . . an amazingly low down time record is being set by Robo-Wrap in the most demanding and highly automated installations throughout the country: the result of still another Lynch engineering advance—the unique hand-over-hand action which holds jaws in sealing position longer, prevents torn roll stock with a unique combination of strong, jerk-free mechanical and hydraulic pull. Team Robo-Wrap with the equally versatile Robo-*Lift*—the automatic bucket elevating conveyor which moves virtually any free-flowing material horizontally or vertically, gently and without re-handling—to reduce packaging costs *all along the line.*



Write now for arrangements to see a Robo-Wrap, Robo-Lift installation in action near you.

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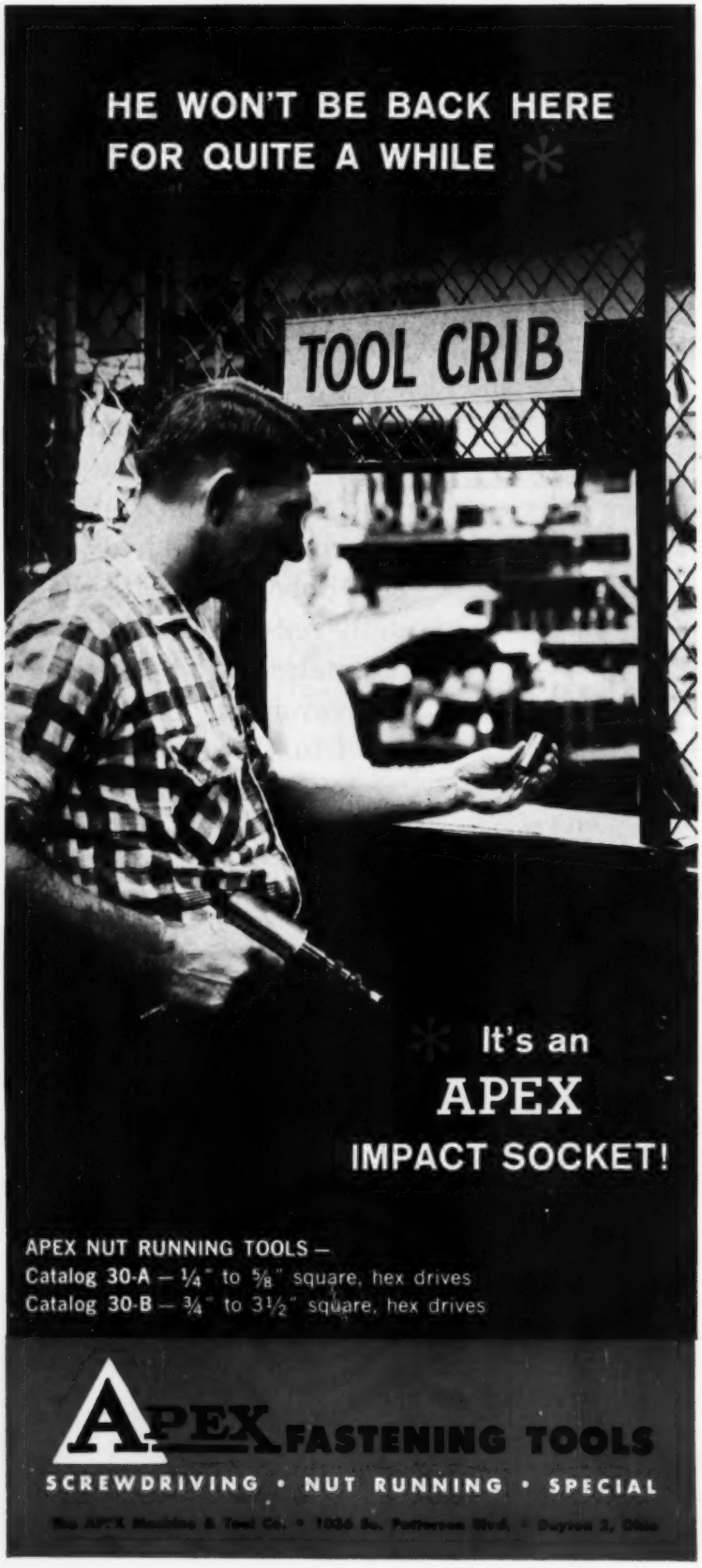
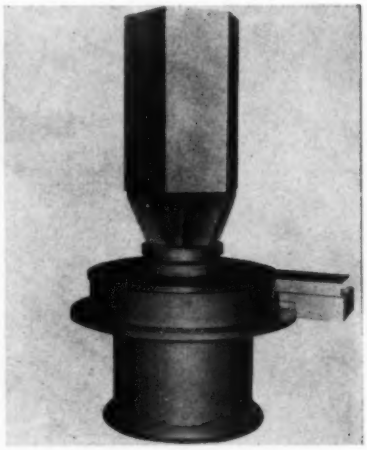
Circle 695 on Page 19


HE WON'T BE BACK HERE
FOR QUITE A WHILE *
TOOL CRIB
* It's an
APEX
IMPACT SOCKET!
APEX NUT RUNNING TOOLS —
Catalog 30-A — ¼" to ⅝" square, hex drives
Catalog 30-B — ¾" to 3½" square, hex drives
APEX FASTENING TOOLS
SCREWDRIVING • NUT RUNNING • SPECIAL

flux solvent is driven off and the flux action initiated. Preheating prior to the soldering operation reduces thermal shock and warpage of boards. The heat bank is also equipped with a regulator for radiation output control. The adjustable board carriers can be used as assembly fixtures while components are assembled to the boards. **Electrovert Inc.**, 489 Fifth Ave., New York 17, N. Y.

Circle 409 on Page 19



Indexing Rotary Table

Mechanical indexing rotary table is designed so it can be set or adjusted to any index pattern desired or any number of indexes desired between the maximum of 24 and the minimum of 4. Once the table has been adjusted to a particular indexing pattern it will repeat that pattern exactly until re-adjusted. An adjusting screw at each station of the table will change the locked position of any individual station from zero to 15 degrees from its true location. A feature of the table is the skip station arrangement which makes it possible to skip 1, 2, 3, or 5 stations each index. This feature plus the individual station adjustment makes it possible to create any desired pattern that requires from 4 to 24 stations. The table is available in 12, 24, and 42-inch sizes. Table can be obtained for either air or hydraulic operation. **Savage Engineering Div., Lithibar Co.**, 345 W. 14th St., Holland, Mich.

Circle 410 on Page 19

Circle 696 on Page 19

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in new cost-reducing series
of DENISON "R-S-T"
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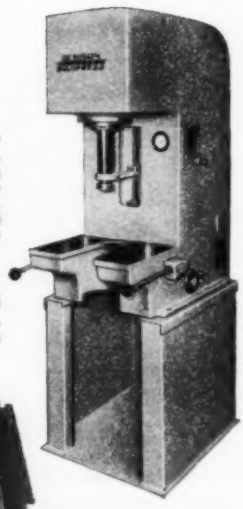
NEW PRESS



NEW "R-S-T" SERIES MULTIPRESS . . . versatile cost-reduction tool on small lots or high production runs. Standard accessories available to increase productive capacity.

FREE BULLETIN . . . write for your copy of our 8-page specification and application Bulletin 324.

NEW PRESS series is designed to cut costs on your toughest production jobs. Here are the key advantages built into this new, ultra-efficient line of presses.

Produces more pieces-per-hour . . . 65% faster approach. Faster return speeds on the hydraulic ram give you more cycles-per-minute.

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PUMPS • MOTORS • CONTROLS

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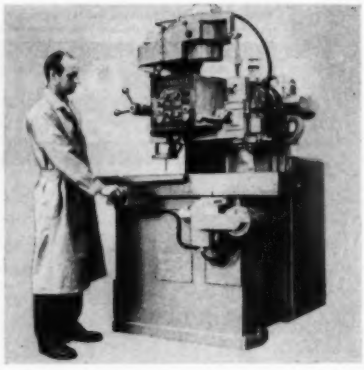
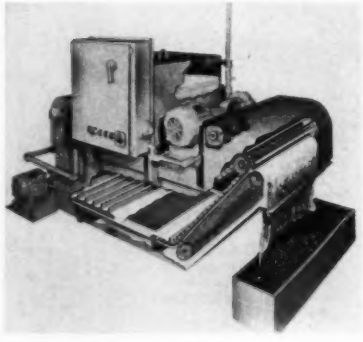


Tracing Profiler

Designed for 360 degree profile milling under tracer control, machine operates by following a prepared sheet steel template to reproduce irregular 2-dimensional shapes. Unit, designated Magnetrace, is equipped with a 5 hp spindle drive and provides 7 speed changes with a total range of 375 to 5200 rpm. The only tooling required is a suitable work-holding fixture, a mild steel template, and a tracer stylus the same diameter as the cutter. **Pratt & Whitney Co. Inc.**, Charter Oak Blvd., West Hartford 1, Conn.

Circle 411 on Page 19



Coolant Filter

Automatic unit can operate with pressure and vacuum on the media because the unit is designed so the media travels on the bottom of a settling tank and above a vacuum box. Dirty coolant returning from the machines enters the filter approximately 18 inches above the floor. The dirt laden liquid passes downward to the filter media where all contaminants are removed. Dirt remains on tke media and the clean

RIVETT SQUAREMASTER "100" CYLINDERS

Unfailing POWER for MILLIONS of cycles!

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1. Piston rod. Ground and polished alloy steel. Hard chrome-plated. **2.** Piston rod bearing. Replaceable cartridge-type. **3.** Piston packing adjusts automatically. V-block packing minimizes friction. **4.** Correctly stressed tie rods. **5.** Cushion bushings. Bronze, floating type. **6.** Ports rotated to any 90° position. **7.** Steel covers. Take minimum mounting space.

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RIVETT furnishes a complete power package

AIR AND HYDRAULIC—VALVES, CYLINDERS, POWER UNITS

Member — National Fluid Power Association

Circle 699 on Page 19

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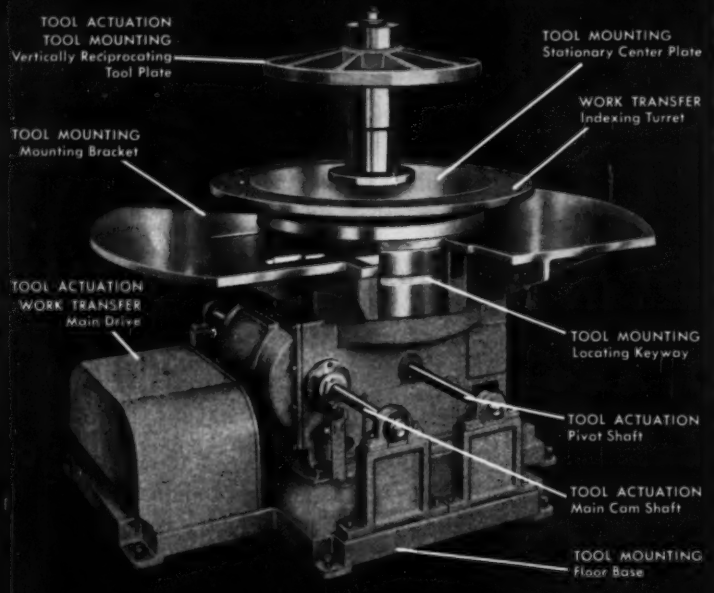

...of
- Tool Actuation
- Tool Mounting
- Work Transfer

...in
Indexing Machine Chassis

for Automatic Processing and Assembling Machines

Over 300 tested and proven standardized models of Turret and In Line Machines available to make...

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Designers and Builders of Automatic Assembly and Processing Machines

liquid passes to the suction of the filter pump. The coolant then can be pumped either directly to the machine or to a clean coolant reservoir. When the media is completely contaminated a scraper conveyor and the media travel to discharge the sludge into a hopper. **Hydromation Filter Co.**, 19661 Schoolcraft Ave., Detroit 23, Mich.

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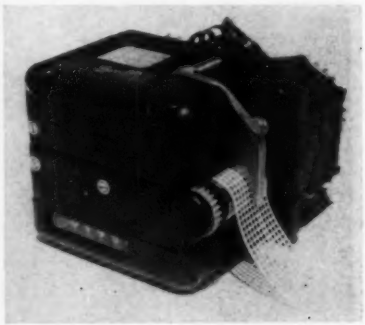


Tape Reader

Explosion-proof, medium-speed tape reader can operate at −65 F, with shock and vibration forces up to 20 g's, and operating rates up to 60 codes per second. Model FR-2, which uses a latch-interlocked cam system for read and feed, can pass a 50 hour salt spray test, is capable of 5, 6, 7, or 8 level operation. Either a single form A or transfer form C contact is provided per sensing pin position while two transfer contacts are available for the common or ambiguity resolving contact. Reader contact closures of up to 240 degrees of drive shaft rotation are provided for readers operated at speeds up to 30 codes per second and up to 180 degrees for readers operated up to 60 codes per second. Optional feature of the reader is a solenoid operated clutch that permits disengagement of the feed sprocket drum so that either forward or reverse tape slewing can be achieved through appropriate reel drive. A Veeder-Root counter can be provided to count the number of recorded characters that pass the reading station, either during slewing or normal forward or reverse reading. **Soroban Engineering Inc.**, Box 1717, Melbourne, Fla.

Circle 413 on Page 19

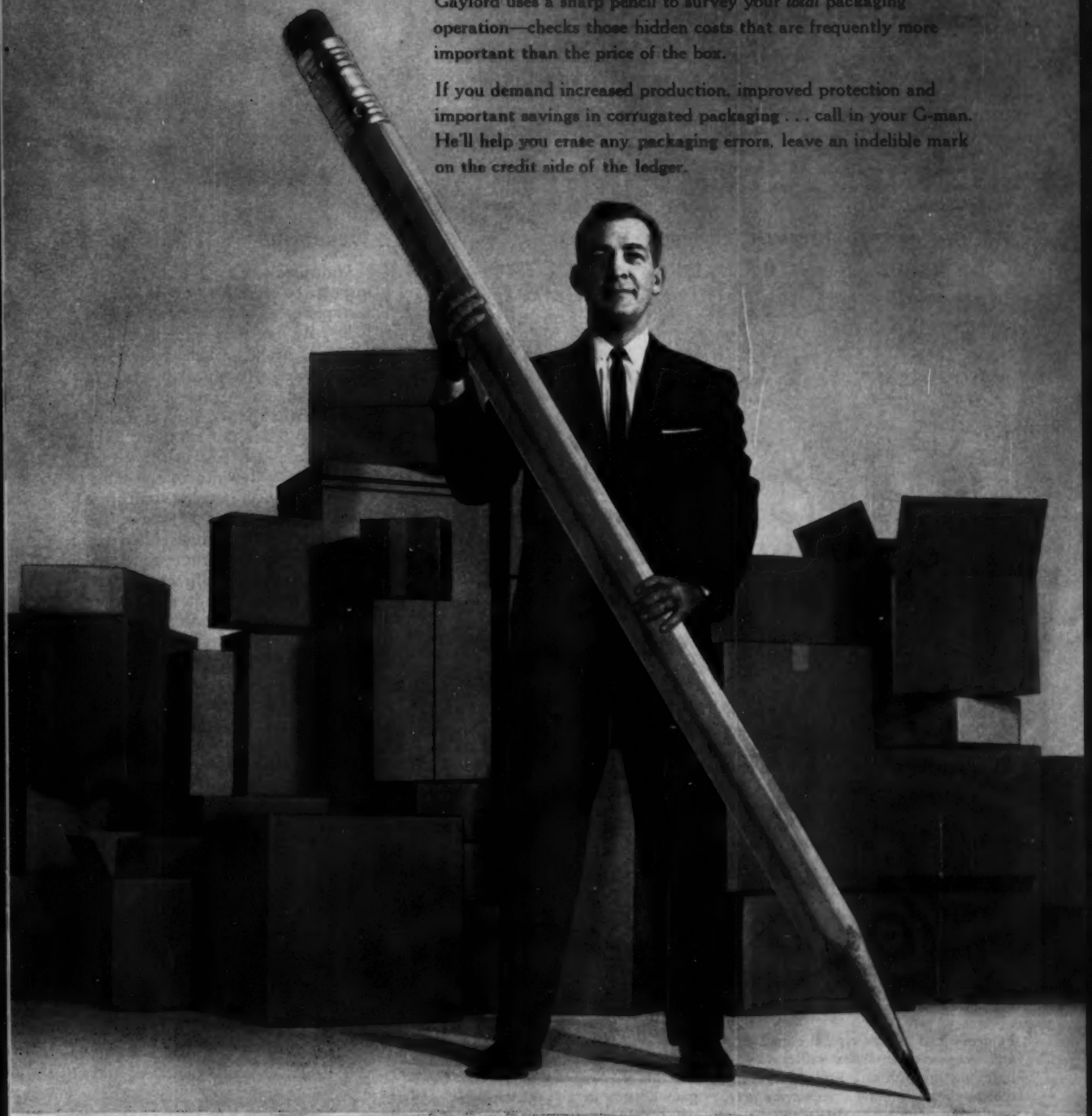
Circle 700 on Page 19

Circle 701 on Page 19→

GAYLORD POINTS OUT
MANY WAYS YOU CAN SAVE IN PACKAGING

Gaylord uses a sharp pencil to survey your *total* packaging operation—checks those hidden costs that are frequently more important than the price of the box.

If you demand increased production, improved protection and important savings in corrugated packaging . . . call in your G-man. He'll help you erase any packaging errors, leave an indelible mark on the credit side of the ledger.



CROWN ZELLERBACH CORPORATION
GAYLORD CONTAINER DIVISION

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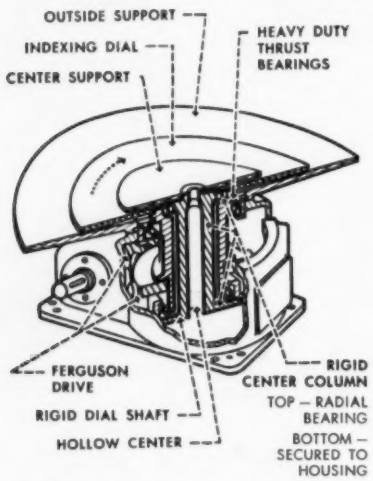
HEADQUARTERS, ST. LOUIS
PLANTS COAST TO COAST

How INDEX TABLE *DESIGN* Affects INITIAL PRICE and TOTAL COST

Study these drawings to see how the design of an index table affects total costs of an installation. Some tables may be priced lower than others initially, but the additional charges for auxiliary items to adapt them to production requirements, added to maintenance and downtime costs, can make a drastic difference in *the total price.*

FIG. 1—FERGUSON INTERMITTOR



The Ferguson Intermittor, indexed by a roller gear drive which operates a minimum of 8,000 hours at speeds up to 2,000 indexes a minute without maintenance, needs no auxiliary locking. It is designed for high speed operation and incorporates rigid integral supports for tooling to eliminate expensive segmental components. The Intermittor dial is supported by tapered roller thrust bearings to withstand heavy loads with little friction. A stationary center tooling support is held rigidly at its top by anti-friction radial bearings and at the bottom by a flanged base bolted to the housing. Hollow center of the support may be used for passage of coolants, fluids, air or vertical shafts to transmit motion to the work surface.

Figures 2 and 3 show typical barrel cam and geneva drive index tables. Their indexing mechanisms limit operating speeds, therefore other components may be "designed down." Shafts and bearings are lighter; frictional support surfaces might be employed instead of thrust bearings and an auxiliary locking or locating device is a costly necessity for even modest accuracy requirements. Tool mounting methods are often provided at additional expense and sometimes even ignored. Difficulties of installation and frequent maintenance downtime can increase total cost drastically.

FIG. 2—BARREL CAM TYPE

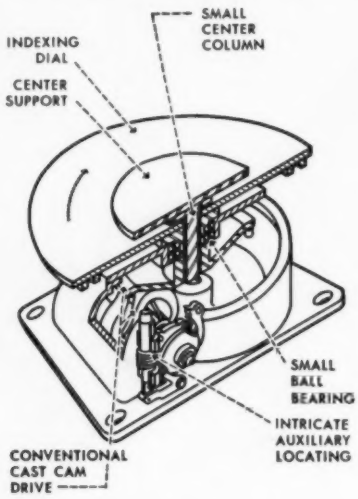
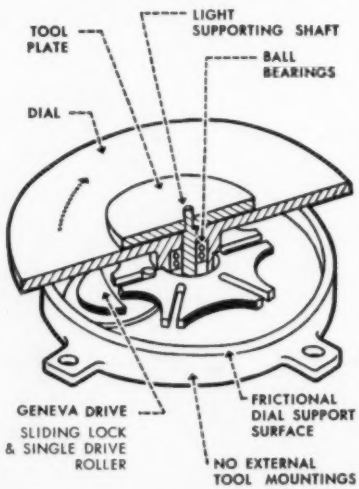


FIG. 3—GENEVA DRIVE TYPE



● SEND FOR CATALOG

Many other advantages result from the selection of a Ferguson Intermittor. Compare designs in new Catalog No. 160 which contains data on more than 175 standard tables. Every design engineer should have a copy. Get yours by writing:

Ferguson Machine Corporation
7818 Maplewood Industrial Court
St. Louis 17, Missouri

Inspection Machine

Unit uses electronic techniques to inspect co-ordinates of machined workpieces to an accuracy of 0.001 inch. An operator controls an inspection probe which has interchangeable tips shaped to locate at any point on a machined part. The probe is supported from a rigid cantilever beam projecting over the worktable and is free to move over the length and width of the table.

Electro-optical sensing units are fitted to the *X* and *Y* axes of the machine. Motion along either axis causes the fringe pattern generated by the associated diffraction gratings to traverse photocells where changes in light intensity are converted into their electrical counterparts. Transistor bidirectional decade counters (one for each axis) record the cyclic variations. Maximum travel of the probe in the *X* direction is 24 inches and in the *Y* direction is 15 inches. **Electronics Div., Farranti Electric Inc.,** 95 Madison Ave., Hempstead, L. I., N. Y.

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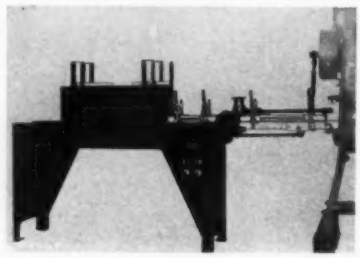


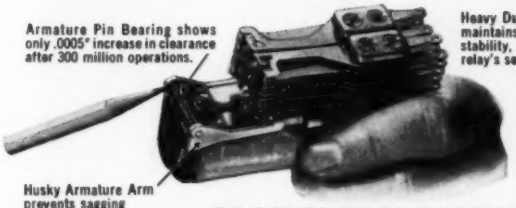
Plastic Strip Feeder

Unit can handle plastic strip stock from ½ to 6½ inches wide, attaches directly to the bolster plate

Circle 702 on Page 19

HERE'S WHY P&B TELEPHONE TYPE RELAYS GIVE YOU

reliable performance over long life


Armature Pin Bearing shows only .0005" increase in clearance after 300 million operations.
Heavy Duty Frame maintains dimensional stability, adds to relay's sensitivity.
Husky Armature Arm prevents sagging or bending.

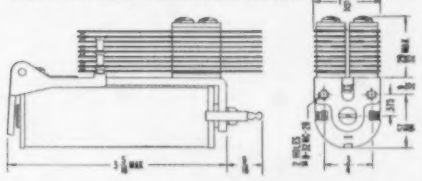
BS SERIES TELEPHONE TYPE

Measure the thickness of the BS series armature arm. You will find the cross section area is greater than ordinary relays of this type. Here is the kind of quality that spells dependability.

Observe that the stainless steel hinge pin runs the full width (not just half) of the armature, providing optimum bearing surface. This pin, operating in a stainless steel sleeve, shows only minimal wear during nearly a *third of a billion operations.*

Best of all, P&B quality costs no more. A whole new plant is being devoted to the production of high performance telephone type relays. Your nearest P&B sales engineer will be happy to discuss your relay problems. Call him today.

BS SERIES ENGINEERING DATA



GENERAL:
- **Breakdown Voltage:** 1000 volts rms 60 cy. min. between all elements.
- **Ambient Temperature:** −55° to +85° C. +125° C available on special order.
- **Weight:** 9 to 16 ozs.
- **Terminals:** Pierced solder lugs; Coil: One #16 AWG wire Contacts: Two #18 AWG wires
- **Enclosures:** Dust covered or sealed

CONTACTS:
- **Arrangements:** DC—up to 28 springs AC—up to 24 springs
- **Material:** 1/16" dia. twin palladium. Up to 1/4" dia. single silver. Other materials on special order.
- **Load:** 4 amps at 115 volts, 60 cycle resistive
- **Pressure:** 15 grams minimum

COILS:
- **Resistance:** 100,000 ohms maximum
- **Current:** 10 amps maximum
- **Power:** DC—50 Milliwatts per movable arm. Greater sensitivity on special order. AC—17.9 volt-amps.
- **Duty:** Continuous
- **Treatment:** Centrifugal impregnation
- **Voltages:** DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

MOUNTING: Two #8-32 tapped holes 3/4" o.c. Other mountings on special order.

GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.

LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.

TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

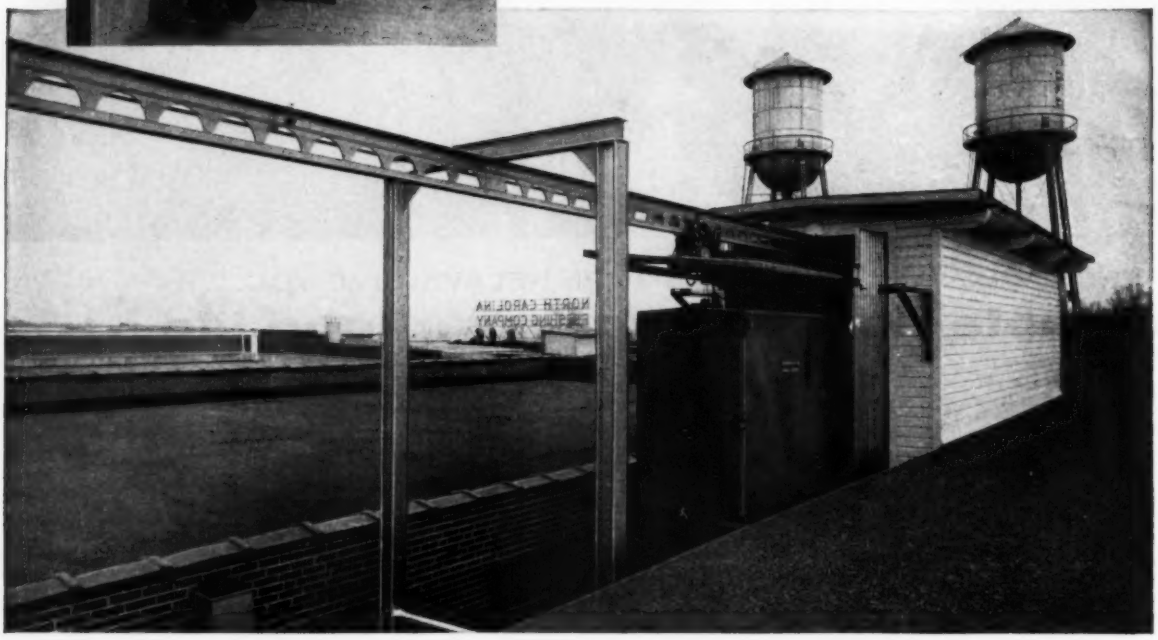
Circle 703 on Page 19

Uses Skyway For Handling Materials AUTOMATICALLY

Completely Pays for Itself Every Three Years

Loading a van on the second floor of a building. This same van also may be lowered to the floor below for loading. Although the building at this end of the system is quite old, the Cleveland Tramrail equipment was easily installed.

For years this vast roof area did nothing more than provide protection from the weather. Now it is being used profitably for materials handling. Illustrated is the van emerging from the penthouse.



BY erecting a Cleveland Tramrail materials handling system over the roofs of its buildings, a large plant is able to transport materials between departments located in widely separated buildings at very low cost.

Because the system operates automatically, the Tramrail carrier travels back and forth without any operator. The carrier van is loaded or unloaded at convenient areas inside the buildings. Pressing a button sends it on its way. It rises vertically to a penthouse on the roof. Then it makes its run over the track system to the penthouse at the other end. Here it lowers to the floor inside for loading or unloading.

The system eliminates considerable floor traffic and saves space required for wide aisleways. It operates at any time, day or night. Inclement weather does not hinder it. The system requires only a fraction of the maintenance necessary for floor handling equipment. It does not wear or damage floors. It is a big aid to safety. In addition to these important benefits, the Cleveland Tramrail system makes tremendous time savings — enough to completely pay for the entire installation every three years.

Cleveland Tramrail has had wide experience in automatic dispatch materials handling systems of many types. Our engineers will welcome an opportunity to work with you.

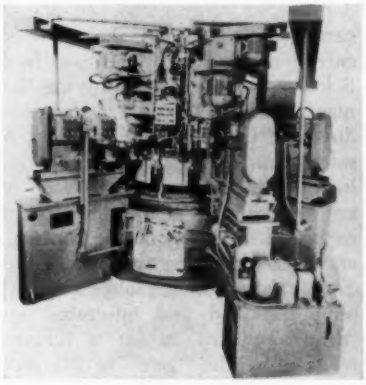
CLEVELAND TRAMRAIL

Overhead Materials Handling Equipment

CLEVELAND TRAMRAIL DIVISION • THE CLEVELAND CRANE & ENGINEERING CO. • 1319 E. 290 ST. • WICKLIFFE, OHIO

of a blanking press. It will automatically feed strip material from a magazine on top of the machine, through a heating oven, into a roll feed, and then into a blanking die. The feeder can be used for blanking hot or cold phenolics, fiber, hard rubber, compositions, and comparable materials. The machine is synchronized with and driven by an adjustable cam mounted on the end of the press crankshaft with a connecting rod to the roll feed. A hinged oven cover provides easy accessibility. Features of the unit include an interchangeable roll feed and a drawer-type belt assembly unit that permits easy removal of the belt. **Technical Design & Development Co. Inc.**, 465 Naugatuck Ave., Milford (Devon), Conn.

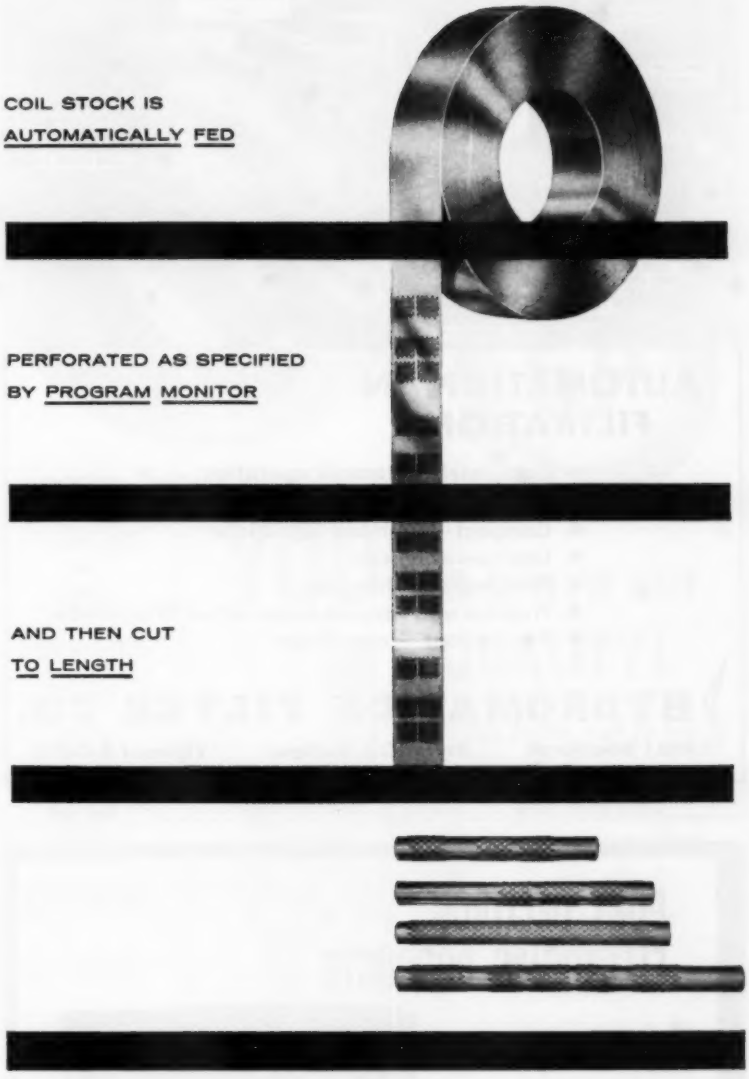
Circle 415 on Page 19



Rotary Indexing Machine

Machine automatically performs 41 operations on compressor heads, cycles each part twice. Model 394-8 has a 48-inch diameter table and a 10-station automatic hydraulic index to drill, ream, spotface, chamfer, and mill 375 pieces per hour. Double fixtures are used, and with each index, the operator removes a completed part from the second position of the fixture, transfers a part from the first to the second position, then loads an unfinished part into first position. Cycle time is 9.6 seconds. Each of the units have independent feeds and speeds, permitting adjustment without affecting the entire machine. **Morris Machine Tool Co.**, 2011 Eastern Ave., Cincinnati 2, Ohio.

Circle 416 on Page 19



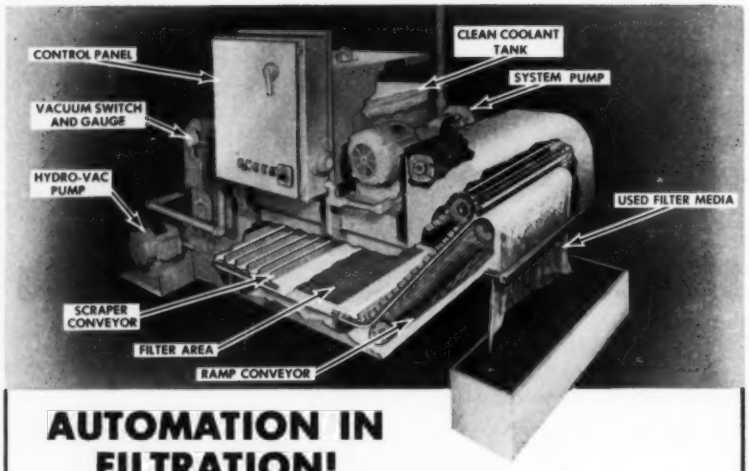
PROGRAMMING WITHOUT TAPE WITH ONE SET OF TOOLS

Skip punching device, actuated by a repeating type counter, programs production of automotive muffler tube blanks in standard V & O inclinable press. Auxiliary counter controls blank cut-off. Varying perforation patterns are achieved with one set of tools. Integrating standard type mechanisms such as these to effect cost reduction illustrates the keen abilities that Emhart press experts can apply to your work improvement projects.

Emhart Manufacturing Co.
Hudson Div., Hudson, N.Y.
Formerly V & O Press Div.

EMHART

Circle 705 on Page 19



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HYDROMATION FILTER CO.

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Circle 706 on Page 19

POST DECITRON ELECTRONIC PRODUCTS

Keeps tabs on hourly production *and* count . . . too!

MODEL P2 RM

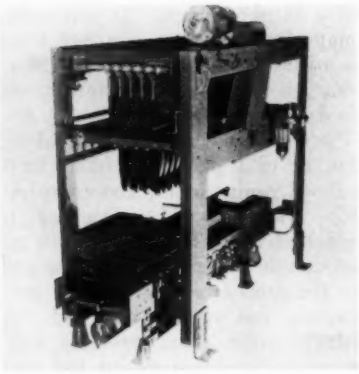
The Post P2 RM is a preset electronic counter which **also indicates hourly production rate** on a two-scale rate meter. By using this dependable component in conjunction with sheet fed machines, conveyor lines, small parts manufacturing, etc., you have the benefit of "batch" counting desired quantities. At the same time you'll be able to keep tabs on your production flow. A visual totalizer indicates unit or total batch counts.

For complete details write: Decitron

ELECTRONIC PRODUCTS DIVISION

Post Machinery Co. | 173 Elliott St., Beverly, Mass.

Circle 707 on Page 19



Case Packer

Case feeder and container loading mechanisms in "piggy-back" arrangement will load cans or bottles, are adjustable for use with two, three, or four lanes. Model 860 AA can cycle at a rate of up to 25 cases per minute, packing full or half-depth fiber, corrugated, or plastic cases, with or without partitions or carry-home cartons. The case feed is located under the loading mechanism, can be in the same or opposite direction to the container flow. A safety control stops the unit if the load is incomplete, if the case is not presented, or if it is improperly registered. Loading of the containers is cushioned in two ways—the case is raised on a platform to receive the load and minimize the "drop" and the impact is further reduced by the "give" of the air-actuated platform. **Portland Div., Emhart Mfg. Co.**, Portland, Conn.

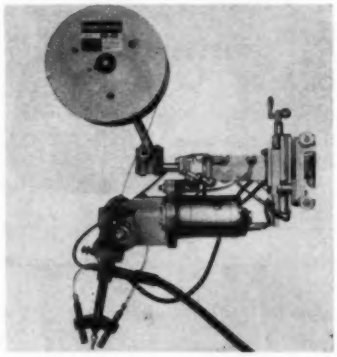
Circle 417 on Page 19

Orienting Belt Elevator

Orienting belt elevator can handle a wide range of rolling or

sliding parts, is available with or without *demand feed* control. Elevating mechanism consists of a motor driven steel chain belt with steel cleats which carry the parts up to the discharge chute where they roll or slide, completely or partially oriented, depending on the shape of the part. Discharge can be from the left or right. Where further orientation is required, tracking devices can be attached to the discharge chute. Storage capacity of the hopper is 15 cu ft. **Industrial & Automation Div., Radio Corp. of America,** 12605 Arnold Ave., Detroit 39, Mich.

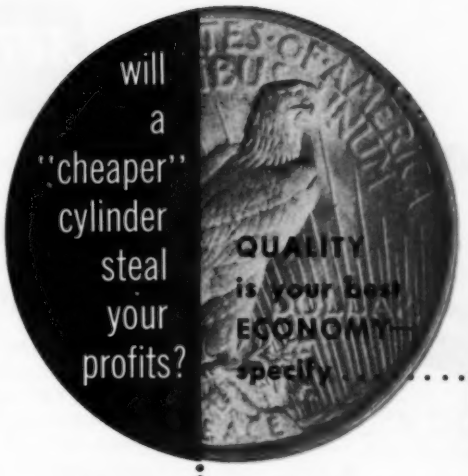
Circle 418 on Page 19



Wire Feed Welder

Welding equipment can continuously feed weld wire without any lag or slowdown. Feature of the equipment is an automatic welding head (shown) that is coupled with a 100 per cent duty cycle, 600 amp, constant-potential power source. The welding head has an infinitely variable-speed motor and a two-speed mechanical gear shift that is designed to provide high-torque power to drive the wire smoothly and without interruption. It can achieve wire speeds from 55 to 1200 ipm. Electronic control panel compensates for line voltage fluctuations and varying resistance in driving the wire. The crater fill circuit contains a vernier adjustment that can control wire speed and a dial-controlled slope of current decay that can be changed to suit particular applications. The power source provides infinitely variable voltage control from 0 to 45v. **Welding Products Div., A. O. Smith Corp.,** Milwaukee, Wis.

Circle 419 on Page 19



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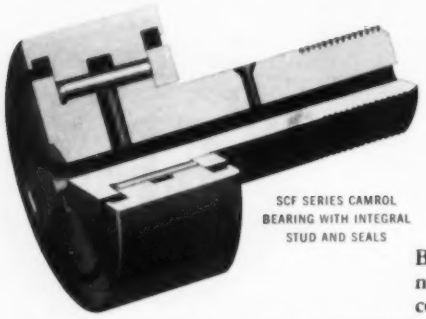
Circle 708 on Page 19

AUTOMATION TIPS
by McGill

Specify **CAMROL**® bearings with assurance of improved performance—dependable long life



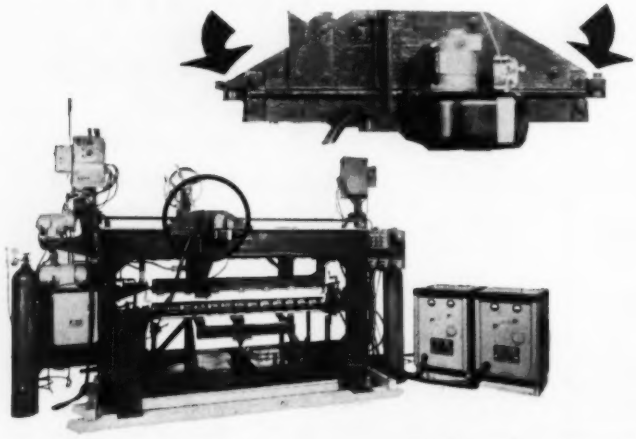
SCF SERIES CAMROL BEARING WITH INTEGRAL STUD AND SEALS

McGill CAMROL bearings are proven with over 25 years' application experience and gradual product improvement. You can rely on their designed-in ability to accept the intermittent shock and heavy load of cam action, guide and support roller applications.

Built for stock in roller diameters from ½" to 4", CAMROL bearings eliminate the procurement and assembly of bolts, rollers, end washers and similar components of improvised followers.

The CF series (with stud) and the CYR series (for shaft mounting) are available also with integral seals for protection against contamination. Lubricant is retained to avoid frequent relubrication. The following are typical of millions of CAMROL bearings serving industry. Ask McGill engineering to held with your automation problems.

CYR SERIES CAMROL BEARING FOR SHAFT OR YOKE MOUNTING

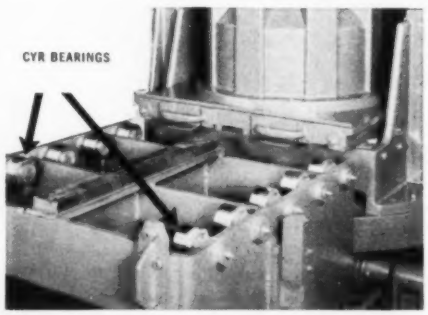


CAMROL CF bearings insure smooth and accurate indexing of welding carriage for ACRO WELDER

ACRO WELDER MANUFACTURING COMPANY uses McGILL bearings in many applications to reduce friction, minimize wear associated with plain bearings and assure accuracy in their welding machines.

In the special purpose welder shown, sealed CAMROL bearings support and guide the linear indexing carriage with assured accuracy and reduction of friction. Integral seals protect bearing life and cut re-lubrication needs.

The 300 pound carriage indexes at a speed of 200 IPM through a 5" distance and is then slowed to a speed of 100 IPM for a 1" weld length, accomplishing 476 welds to join 17 bars to 14 cups. CAMROL bearings help improve machine performance that cuts welding time from five to 1/3 of a man-hour per assembly.



CAMROL CYR bearings are trouble-free and accurate in NATCO machines

The photo shows CAMROL CYR Series which support and convey jig-type fixtures into NATIONAL AUTOMATIC TOOL COMPANY multi-spindle machines which drill and ream stainless steel weldments for jet engines.

Twenty-four CYR bearings reduce friction and provide smooth trouble-free and accurate operation in these machines.

NATIONAL AUTOMATIC TOOL COMPANY reports that performance of McGill CAMROL bearings has been excellent and that they have "never had a service report as to the malfunction of a McGill bearing."

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MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING COMPANY, INC.
BEARING DIVISION, 401 N. LAFAYETTE STREET, VALPARAISO. INDIANA

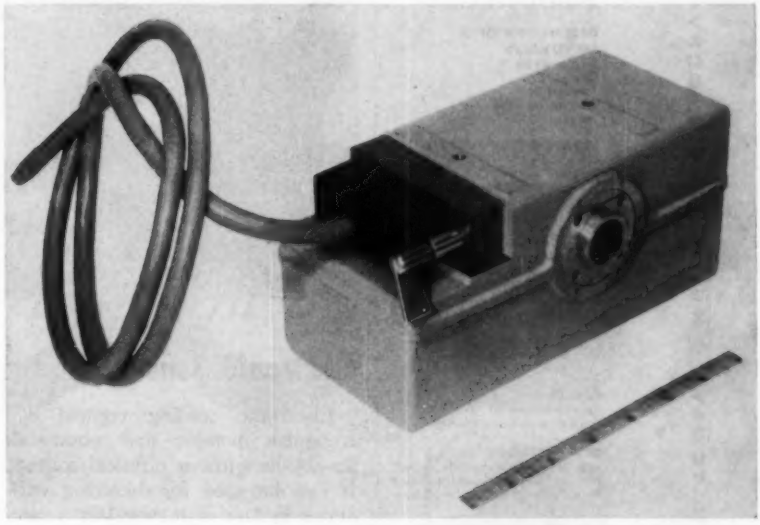
Circle 709 on Page 19

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems.

For detailed information and literature, use card page 19.

Analog-To-Digital Converter



UNIT, designated Mem-O-Tizer, is a combination analog-to-digital converter and storage accumulator for signals representing time, events, pieces, or quantities. It employs the basic principles for the electromechanical conversion of analog inputs for digitizing temperature, time, level, weight, flow, rotation, pressure, and position. Designed by **Automation Div., Telechrome Mfg. Corp.**, 26 Edison St., Amityville, N. Y., the digitizer uses no electronic components from input shaft to memorized output.

An integral input shaft and first stage code drum are contained in the digitizer. Additional drums, as required, are geared to the first drum. Each drum is composed of concentric cams. Each cam is profiled with a series of high, intermediate, and low faces. Solenoid-operated sensors, each with a simple position-locking device, sense the drum profile. Each sensor closes either of two switches in the high or low position. No switch closure occurs in the intermediate position. A detent wheel on the drum is engaged to accurately position the cam profile during the initial motion of the solenoid. All drums are sensed simultaneously. All units are equipped with lost motion couplers which permit readout while the input shaft is turning at speeds up to 250 revolutions per minute.

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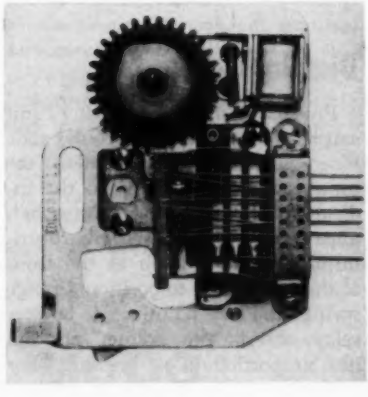

Electromechanical Logic Switches

Line of electromechanical logic switches can be used in large and small data handling systems for tape data assembly and translation, code conversion, storage and memory, computing, format conversion, and numerical control. When combined with electronic systems, the switching elements perform programming, logic switching, and other functions. The switches, which are basically electromechanical power amplifiers of pulsed bistability with delayed configurations, consist of three elements—a delay element, a bistable element, and a number of *AND* gates associated with either the assert or negative side of the bistable element. The three essentials involved in producing a switching action have been separated. These three essentials are: The power required to move the switch element, the dynamic characteristics of the

ELECTROHYDRAULIC SERVOMECHANISMS IN INDUSTRY. . . .

a discussion of components and applications.

CONTENTS:

DESCRIPTION OF A SERVOVALVE
Single stage
Two-stage
Three-stage
Mechanical feedback
Industrial

TYPES OF SERVOVALVES
Flow control
Pressure control
Pressure-flow control
Dynamic pressure feedback
Acceleration switching

APPLICATIONS OF SERVOVALVES
Position control
Fixed position control
Point-to-point position control
Variable position control

Velocity controls
Constant speed control
Feed-rate control

Force Controls
Tension control
Programmed force control

CASE HISTORIES
Spar mill tracer controls
Printing press steering control
Point-to-point drilling machine control
Contour cavity mill control
Press brake tilt control

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Title .....

Duties .....

Company .....

Address .....

Principle products .....

MOOG SERVOCONTROLS, INC.
INDUSTRIAL DIVISION, EAST AURORA, N. Y.

Circle 710 on Page 19

electromagnetic element, and the delay inherent between the time a pulse is applied and the time switching occurs. A feature of the switch is that one of the two logic states available is always present in complete mechanically stable form. The power may be removed from the system without change in its logic state. Other features include short term switching response delay, multiple set contact arrays and repeatable operate and drop-out times. **Tally Register Corp.**, 5300 14th Ave., N. W., Seattle 7, Wash.

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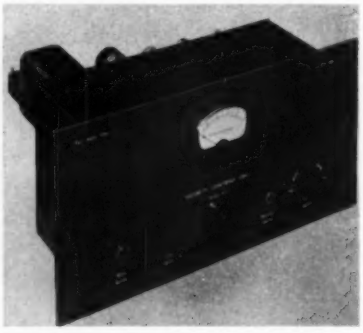

Electronic Sensor

Electronic sensing control can recognize metallic and nonmetallic objects without physical contact. It can be used for detecting variations in flow of material in chutes, indicating changes in liquids flowing through pipelines, and denoting broken bits on automatic drilling and tapping machines. Other uses include: Counting products in closed cartons, sensing missing caps on filled bottles prior to packaging, and controlling the position of cans on conveyors prior to filling operations.

Model 400 consists of a sensing element or probe connected by coaxial cable to an electronic control. It can be set up to any given constant at a given time interval. When the unit recognizes the error it indicates whether the sensed objects are too large or too small, too far or too near to a predetermined position or setting. Detection can be expressed in various ways—stopping a machine, actuating a rejecting or correcting device, or signaling for action by an attendant. **Security Controls Inc.**, 503 Franklin St., Buffalo 2, N. Y.

Circle 422 on Page 19

Stepping Motors

Devices are used to rotate potentiometers, counters, rotary switches, tape advances, and various control mechanisms. They feature a clutch mechanism which replaces the use of ratchets and permits the translation of pulses to incremental shaft positions with 99.9999 per cent accuracy and dependability. The motor breaks at the end of each step for positive locking of the load. It is available in unidirectional and bidirectional models, ranging in weight from 4 to 13 ounces, with angular increments of 36 degrees per pulse, up to 15 steps per second, and load capacity up to 2 lb-in. starting torque. **G. H. Leland Inc.**, 123 Webster St., Dayton 2, Ohio.

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Dial Indicator

Process variable indicating unit can be changed with a recorder slide when necessary. In operation, the input signal transmitted to the indicator is amplified by a force balance servo motor. A set point transmitter utilizes a knob at the front of the instrument to position a range spring and set pointer. A booster relay coverts the pointer position into proportionate air pressure. For

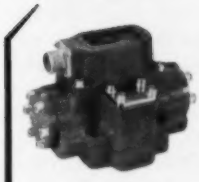
industrial servovalves

rugged, reliable . . .

MOOG: INDUSTRIAL DIVISION

The Moog Series 71 electrohydraulic servovalves excel in all industrial applications that require superior performance combined with rugged reliability. A low sensitivity to oil contamination plus a large field-replaceable filter provide optimum performance for extended periods of time. Immediate production requirements can be accommodated from stock in flow ranges from 0.25 g.p.m.

one of the industrial products group including:



High flow servovalve valve positioner servo amplifier, (illustrated at left). In addition: integrated hydraulic power packs, mounting manifolds and hardware, electrohydraulic servo-actuators can be provided.

Moog's Industrial Division was established for the purpose of developing commercial applications for electrohydraulic servomechanisms and to serve industry in this new and rapidly growing precision control area. The division offers both integrated electrohydraulic control systems and a complete line of servocomponents.

SEE FACING PAGE FOR ADDITIONAL INFORMATION

MOOG SERVOCONTROLS, INC. INDUSTRIAL DIVISION EAST AURORA, N. Y.

recording purposes, the indicator slide of the instrument can be replaced in less than one minute by a 4-inch strip chart. **Taylor Instrument Companies**, 95 Ames St., Rochester 1, N.Y.

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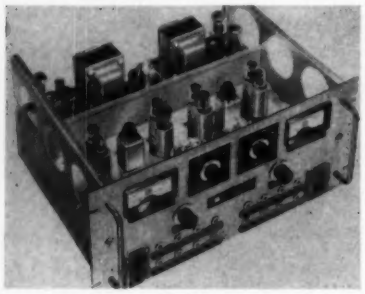

Servo Controller

Combination unit, composed of a controller, servo-amplifier, and power supply, is adaptable for use in dynamic process control systems. It can perform any of three control functions—summation, integration, and derivative. Designated the Series 800, the unit can be applied to the control of any electrically-measurable variable, is especially suitable when used with electrohydraulic actuators where large mass positioning in the final control element is necessary. A mode-selector switch has settings for *Automatic, Automatic Balance, Manual Balance,* and *Manual.* **Products Div., Compu-Dyne Corp.**, 687 S. Warminster Rd., Hatboro, Pa.

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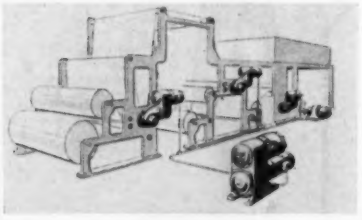

Motor Drive System

Suitable for use in paper, plastics, or textile industries, ac motor drive system provides variable speed for power applications involving coating, laminating, drawing, embossing, bleaching, or dying operations. The system operates as an integral unit. Variable speed drives are used to trim tension or positively drive the material instead of pulling it through by lead elements. Unit, designated Varidyne, controls the speed of ac slave motors through frequency variation of 3 phase current. When delicate or unstable strip material is being processed, the Varidyne with is coordinated slow speed, and smooth stop and start, prevents undue strain on the web system. Emergency braking can be applied which will bring the web to a rapid stop without breaking the web or creating excess slack. **U. S. Electrical Motors Inc.**, Box 2058 Terminal Annex, Los Angeles 54, Calif.

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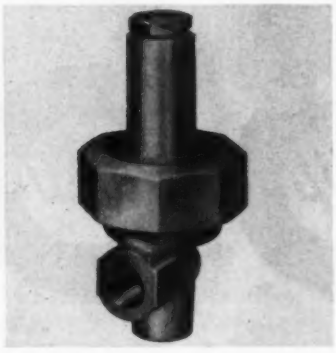

Corrosion-Resistant Valve

Polyvinyl chloride relief and back pressure valves are designed to protect positive displacement pumps metering process liquids such as dilute sulfuric acid, hydrofluosilicic acid, and hypochlorite solutions from excess pressures. The relief valve can withstand presures to 400 psi at 68 F and to 200 psi at 140 F. A feature of this valve is its tight shutoff below set pressure. The back pressure valve can withstand pressures to 200 psi at 140 F. It maintains a head on the controlled volume pump discharge above suction pressure so that a liquid can be metered into a low pressure system. Both units are available in ¼ and ½-inch sizes. Kel F or Teflon diaphragms protect the upper internal parts from contact with corrosive liquids. The lower valve body is constructed of polyvinyl chloride. **Milton Roy Co.**, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

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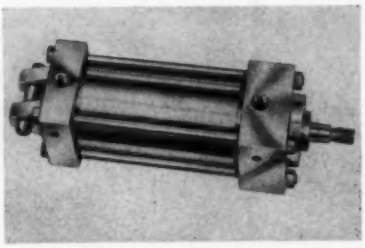

Low Pressure Cylinder

Line of low pressure air and hydraulic cylinders is available in 1½ through 8 inch bore sizes. Capacites are 250 psi air and 400 to 1000 psi hydraulic, depending on the bore size. Types of mountings include: Side lug, center lug, basic, tie rod, flush side, front flange, rear flange, trunnion, clevis, and double rod. A feature of the cylinder is the pressure safe tube seal which is located on the outside diameter of the tube and forms a positive seal at all pressures from zero to maximum. The mountings are welded to one piece steel heads and will not come lose due to vibration. **Hanna Engineering Works**, 1765 Elston Ave., Chicago 22, Ill.

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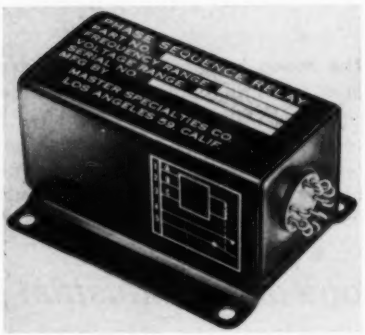

Sequence Relay

Device provides automatic monitoring of three phase power. If incorrect phase sequence is applied, the relay prevents current from passing through to equipment which could be damaged in this manner. In operation, the unit senses the phase sequence, and operates to close a contact when the applied phase sequence is correct. The relay contact in a resting state is open, making the unit fail-safe. The contact remains open (non-operative) with an incorrect phase

Circle 711 on Page 19→

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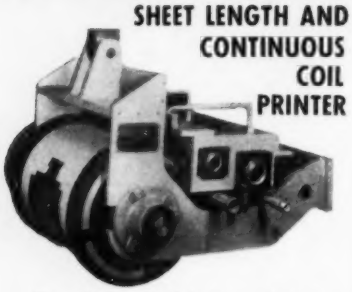
PRODUCT
PRINTERS

SHEET LENGTH AND CONTINUOUS COIL PRINTER

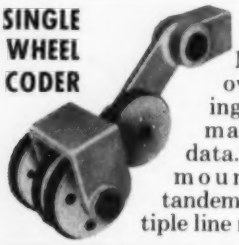


For line or friction drive continuous marking . . . or electronic control for spot printing.

MULTI-WHEEL PRINTERS

Hand rollers or in-line units for continuous overall sheet marking

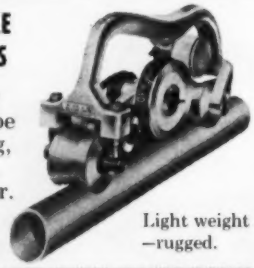
SINGLE WHEEL CODER



Mounted over moving stock to mark code data. Can be mounted in tandem for multiple line marking.

PORTABLE PRINTERS

For Bar and Tube Marking, any diameter.



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3962 FORBES AVENUE
PITTSBURGH 13, PA.

Circle 712 on Page 19

sequence. The contact remains open when any lead, or any combination of leads, are opened and/or grounded. Relay is rated for 10 w maximum, has an ambient temperature range from −55 to +71 C. Contacts are 3 amps resistive, 1 amp inductive. **Master Specialties Co.**, 956 E. 108th St., Los Angeles 59, Calif.

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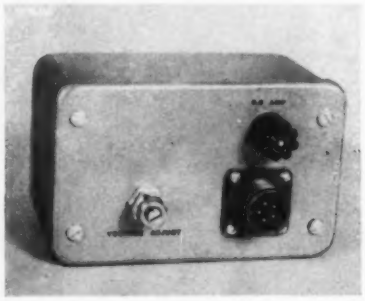

Voltage Regulator

Transistorized unit can be used as a sub-system in an electronic system for regulating direct current from unregulated direct current sources. Output voltages ranging from 6 to 35 v dc are available from inputs ranging from 24 to 45 v dc. The outputs for each model can be varied over a 15 v range by means of a screwdriver adjustment. Load regulation for the unit is 50 mv for 0-0.5 amp load change; residual noise is 1 mv typical; output impedance 0.10 ohm maximum, dc-5kc. Line regulation is ±0.1 per cent or 10 mv whichever is greater. **Valor Instruments Inc.**, 13214 Crenshaw Blvd., Gardena, Calif.

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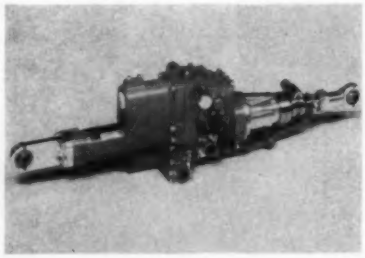
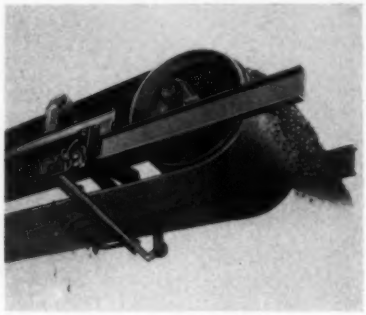


Feedback Servoactuator

Line of electrohydraulic servoactuators features mechanical feedback. No feedback transducer and amplifier are used in this unit. Feedback of piston position to the armature of the input force motor is accomplished by springs together with a precision motion reductive device. Any error or difference between the input force and the spring feedback force is amplified by a variable orifice hydraulic amplifier. The output of the hydraulic amplifier positions a sliding spool valve which supplies flow to the servo-piston. With this mechanical feedback arrangement, the actuator is positioned proporitonal to the dc input current. Open loop gains as high as 120/sec can be obtained. Auxiliary components available include telemetry potentiometers, force or velocity limiters, and shut-off solenoid valves. **Moog Servocontrols Inc.**, East Aurora, N. Y.

Circle 431 on Page 19



Belt Cleaner

Device is designed to gently remove sticky material from high speed conveyor belts. Cleaner consists of a row of thin, spring steel wiper blades, each blade having an individual pressure spring. The wiper blades are set perpendicular to the belt surface, but diagonal to travel of belt. Pivoted connections between the blades and springs permit the wiping edges of the blades to seat uniformly on the surface of the returning belt. As the belt passes over the cleaner, each blade wipes a path clean and dry. As the blades overlap, the entire carrying surface is wiped clean and free from material which would otherwise be ground into the belt by snub pulley and return rollers. The unit is available for any belt width. **Stephens-Adamson Mfg. Co.**, Ridgeway Ave., Aurora, Ill.

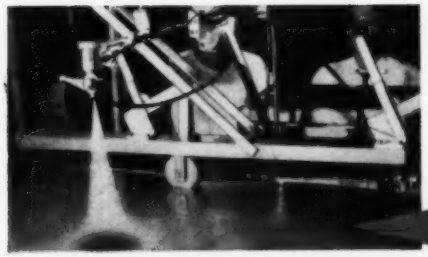
Circle 432 on Page 19

The Man is Sperry Ultrasonics

At Chrysler Corporation he collaborated with methods researchers to develop an improved ultrasonic inspection system. The new system, named SIMAC (Sonic Inspection Measurement and Control), automatically tests sheet steel for internal flaws in excess of 300 feet a minute. Flaws are marked by dye and the faulty steel rejected before it reaches the stamping phase. The resultant quality control assures the most perfect product with the least waste of man hours and material.

Sperry sales engineers are recognized authorities on the application of ultrasonic techniques in nondestructive testing. They are the link that sparks Sperry research and development teams to create the quality control tools industry needs.

When there is a quality control problem, call the man who is Sperry Ultrasonics.



Defective sheet steel is automatically sprayed with dye on the production line at Chrysler's Nine Mile Stamping Plant.

Sperry Products Company

DIVISION OF HOWE SOUND COMPANY

1202 Shelter Rock Road, Danbury, Connecticut

Circle 713 on Page 19

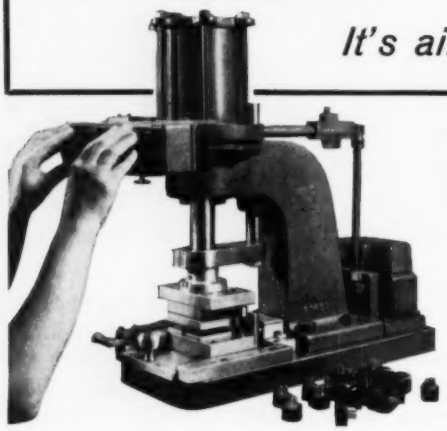
Formula Control Unit

Adaptable for use in blending, proportioning, and batching operations, formula capsule (upper right corner in photo) automatically sets correct proportions of feeds, grains, chemicals, and flour. The pocket-size control consists of a network of miniature electronic components sealed in a shatter-proof protective cover. It is capable of programming the sequence and weighing of up to 24 solid and/or liquid ingredients in a single formula. When the capsule is inserted in the formultor, as shown in the photograph, weight of each ingredient can be preset by laboratory personnel. After the unit has been set (up to 24 ingredients) it is inserted into the receiving slot on a select-o-weigh panel. Precise duplication of the desired formula is assured. **Richardson Scale Co.**, Van Houten Ave., Clifton, N. J.

Circle 433 on Page 19

Solve your "Small Parts" production problems with a **HANNIFIN "HAN-D-PRESS"**

It's air operated!



The husky Hannifin "Han-D-Press" takes operator fatigue out of light production operations where speed is the key to economy. A safe, easy-to-operate Hannifin air-operated bench press can handle these sometimes troublesome jobs better, faster and easier.

RIVETING
STAKING
PUNCHING
PRESSING
ASSEMBLING
MARKING

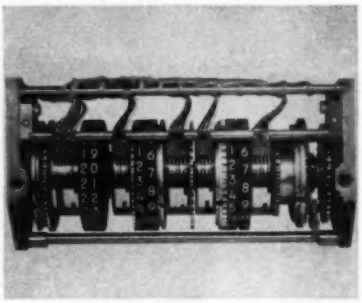
CHECK THESE FEATURES:

- Electric control through Hannifin 4-way solenoid-actuated valve.
- Guided ram. Speed easily adjustable. Automatic return.
- Removable steel base plate. Easy to change job set-ups using alternate work bases.
- Minimum maintenance. Rigid frame; cylinder "tru-bored" and honed.
- Half-ton and one-ton models. Low prices. Immediate delivery.

Call Your Hannifin Man for Complete Information

HANNIFIN COMPANY
541 South Wolf Road • Des Plaines, Illinois

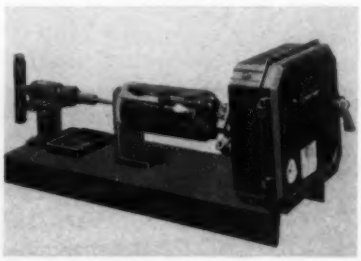
A DIVISION OF PARKER-HANNIFIN CORPORATION



Time Signal Converter

Direct reading analog-to-digital converter will display time values in hours, minutes, and seconds, and simultaneously transmit this information as a coded electrical signal by means of coded drum assemblies and pick-off brushes. Unit is read either continuously or on demand. It is designed for almost any mode of binary expression ranging from simple pure binary (scalar) to coding arrangements such as cyclic binary, binary decimal, or cyclic binary decimal. Range of digits is from 0 to 23 hrs 59 min 59 sec. Operating temperature range is 54 to 77 C; operating pressure range is 14.7 psia to 0.55 psia. **Kearfott Co. Inc.**, 1500 Main Ave., Clifton, N. J.

Circle 434 on Page 19



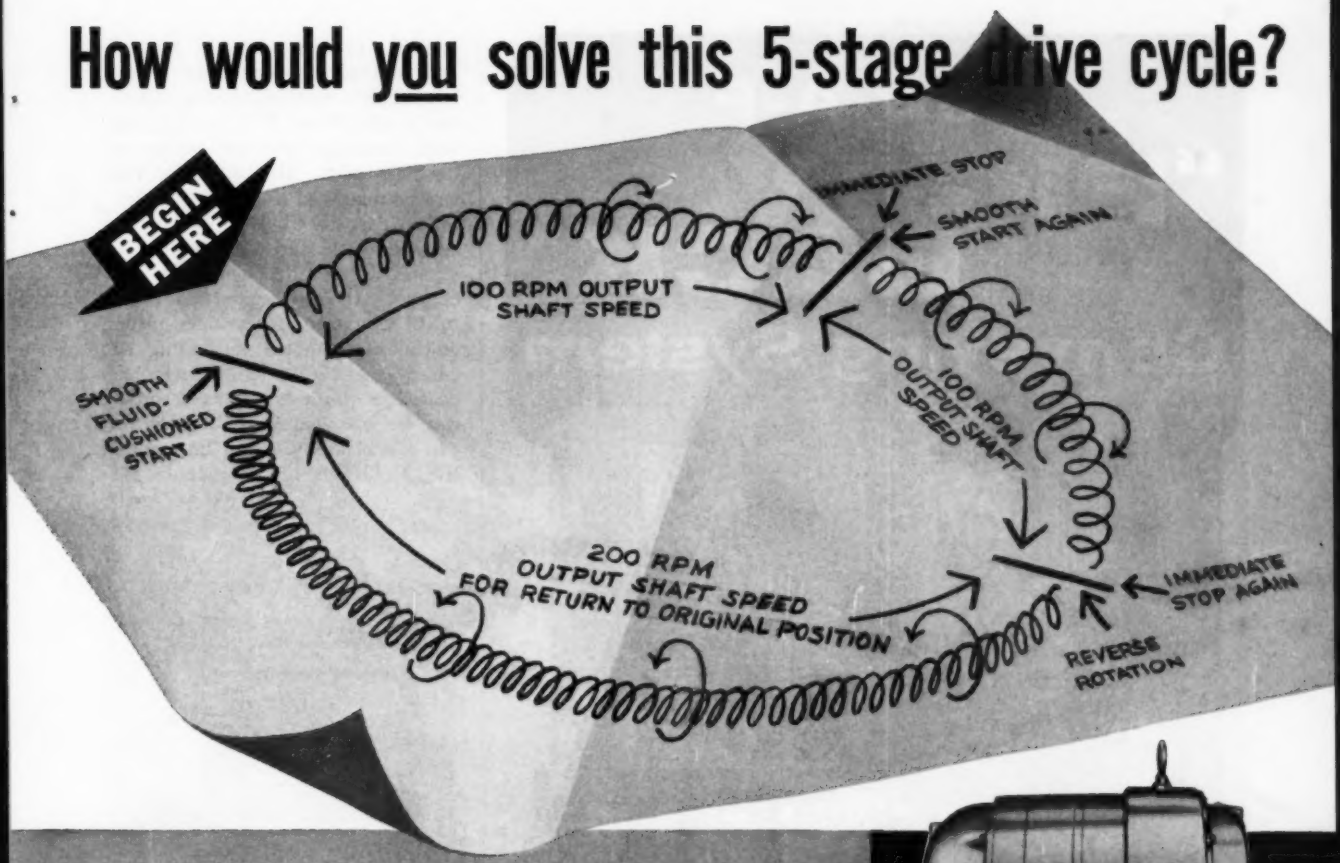
Metering Pump

Pneumatically controlled and powered unit can perform functions such as simple metering, flow ratio

Circle 714 on Page 19

Circle 715 on Page 19→

How would you solve this 5-stage drive cycle?



This one *modern* Reuland power package *does* all five!

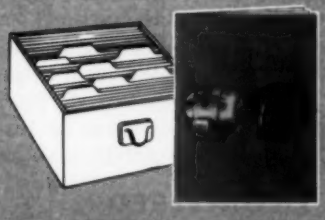
Today's ingenous, automatic machines have demanded a whole new concept in electric motors. No longer will "just any motor do" because the motor now becomes merely an integral part of the modern drive *package*.

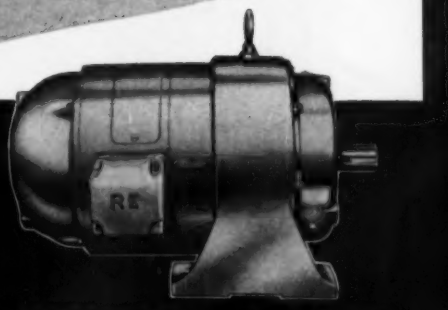
Reuland's "Xpandable Design" idea *originated* this modern new approach several years ago. With this unique system, drives incorporating many varied factors are supplied as a single unit . . . *tailored to the needs of each individual customer.*

Modern Reuland Power demonstrates every day that there *is* something new in electric motors. Whether *your* own drive needs are more complicated, or less, than the above sketch . . . it will pay you to take stock and compare with what Reuland can offer.

Our New General Catalog Will Come In Handy — Sent FREE On Request

Gives details on Reuland's "Xpandable Design" . . . also shows how O.E.M.'s save money by using Reuland's free "Special Motor Library." Get a copy for your files now, for sure.





MODERN REULAND POWER

This unit contains an internal fluid coupling . . . a two-speed reversing duty motor . . . gear reducer . . . and magnetic brake mounted between the reducer and the fluid coupling. It is typical of the literally hundreds and hundreds of tailored adaptations available as a result of Reuland's modern "Xpandable Design" idea.

It is easy to see how this one, compact drive package saves costs and space and weight in comparison to installing separate drive units.

MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

RE®

REULAND ELECTRIC COMPANY
WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES
Refer To Sweet's Product Design File, Section 5a

® REGISTERED TRADEMARK

New A-F "PIGGY BACK" Conveying System

Helps To Double Output Cut Handling Costs

Speed Queen clothes washers and dryers go to market faster—since this new A-F *Job Engineered* Double-Stack Conveying System was installed in the Ripon, Wis. manufacturing division of McGraw-Edison Co.

Crates come off one of three feeder lines from assembly (photo, left) to the automatic stacking units where every second crate is elevated to ride "piggy back" on the crate that comes beneath it. Stacked crates are routed onto one of nine conveyorized storage lines. Photo, right, shows switch-type device transferring "piggy backed" crates from desired storage line to conveyor for delivery to cars.

Machines are pre-selected, through a railroad switch-type device, for loading in semi-trailers or railroad cars. By switching from one line to another, an operator is able to send the proper number of each machine in the correct shipping order.

What is your parts or products handling problem? We may be able to help you transform problems to profits.

Why not write us today?

A-F

A-F *ENGINEERED* CONVEYING SYSTEMS

Also Pre-Engineered Conveyors—
Wheel, Trolley, Roller, Belt
Metal Cleaning and Processing Machines

THE ALVEY-FERGUSON CO. 170 Disney Street Cincinnati 9, Ohio

Circle 716 on Page 19

control, process variable control, and multiple proportioning. Pump is available with maximum capacities ranging from 0.12 to 82.5 ghp, with discharge pressure ranges up to 5000 psig. The pumping rate can be regulated from zero to maximum capacity by adjusting the stroke length and the number of strokes per minute. Controlled discharge is linearly proportional to 3 to 15 psig signal. Cylinder piston and pump plunger positioning accuracy is within 0.002-inch, repeatedly. Unit is explosion proof, can be operated by either air or gas. **Associated Control Equipment Inc.**, P. O. Box 136, Coraopolis, Pa.

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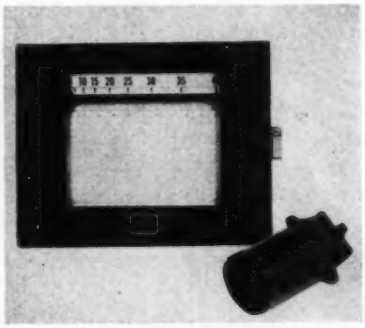


Pyrometer System

System can measure, record, and control temperatures in the manufacture of products such as rubber, synthetic rubber, tiles, roofing shingles, adhesives, cast aluminum, textiles, synthetic and natural fibers, and plastics. Features of the system include direct-reading charts and scales, interchangeable head units, and automatic ambient temperature compensation. It will measure temperatures in ranges from 0 to 200 F, up to 1100 F.

In operation, an eyepiece on the pyrometer unit is placed on the surface to be measured. The thermocouple output from the pyrometer unit is input to a company Dynamaster instrument. The instrument automatically corrects for ambient temperatures and records the corrected measurement. A knob adjustment on this instrument corrects for emissivity of the surface being measured. **Bristol Co.**, Waterbury 20, Conn.

Circle 436 on Page 19

O-M PRECISION GIVES CYLINDERS GREATER EFFICIENCY and DEPENDABILITY

Meets JIC Standards **Fits Where Others Won't**

By machining to micrometer accuracy the working surfaces within O-M Air and Hydraulic Cylinders, these units function with high operational effectiveness and a minimum of routine maintenance.

More than this, O-M precision workmanship is reflected in every engineering and construction detail. These components are designed right to seal right. The ports are readily rotated independently to a desired location. Accurate machining assures perfect piston rod alignment on extreme in and out positions, on maximum or minimum loads as well as on short or long travel.

O-M standard, oversize and 2 to 1 rods have a high yield point that increases fatigue strength. The low coefficient of friction and cushion ball-check valve provide for full-power starts. End plugs are tapped for universal mounting.

Series 101A (illustrated) and Series TH (Heavy-duty Hydraulic Cylinder) are available in a complete range of sizes (1½" to 8" bores) and a full line of mounting brackets. Immediate delivery on many sizes.

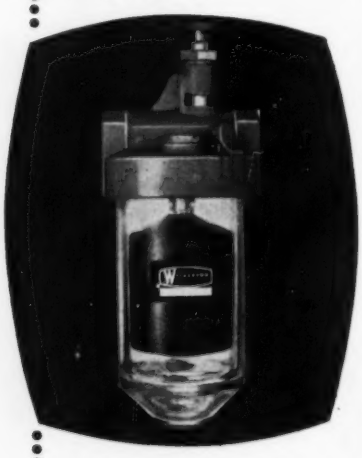
Mail coupon at once for Bulletin 101A and 105 containing engineering data on the two units.

ORTMAN-MILLER MACHINE COMPANY
25 143rd Street, Hammond, Indiana
☐ Have representative call
☐ Send Bulletins 101A and 105

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 717 on Page 19

NOW! *Get*
CONTINUOUS
dependable
lubricating
PROTECTION
with the
WILKERSON
AUTOFILL
Lubricator



Eliminate the needless expense of ruined air tools, equipment and machinery resulting from dry, "forgot-to-fill" lubricators.

The float-operated valve on the Wilkerson Autofill maintains lubricant at a safe level.

- New finger-tip KWIK-CHANGE bowl.
- ¼" to ½" P.T.
- 150 PSI maximum air pressure.
- 250 PSI maximum lubricant pressure.

Complete information contained in new catalog #158 will prove the safety advantages of the Wilkerson AUTOFILL

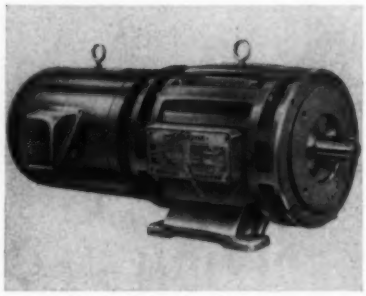
WRITE TODAY

WILKERSON CORPORATION

Dedicated to keeping the NEW in pNEUmatics

1552 West Girard
Englewood, Colo.

Circle 718 on Page 19



Cycling Drive Unit

Electromagnetic cycling drive unit is a fan-cooled clutching and braking package which, when put between the motor and driven equipment, will provide a drive that instantly responds to pushbutton or automatic switching control signals. The motor rotor flywheel inertia helps to accelerate the load when the clutch functions, and subsequently, when the brake stops the load it is unnecessary to decelerate the motor rotor and absorb its high momentum. Forced air cooling is continuous in the unit whether the load output shaft is running or stationary. Drive unit is available in five sizes for power transmission requirements ranging from ½ to 50 hp. **Cycledynamics Inc.**, 19025 W. Davison Ave., Detroit 23, Mich.

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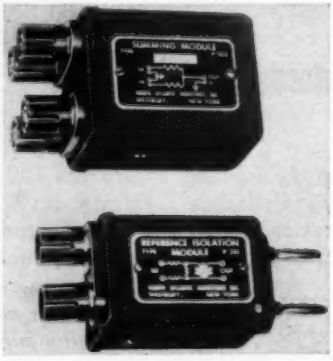

Circuit Modules

Designed for use with company's phase angle voltmeters, circuit modules can also be used with other instruments for transformation ratio measurements, servo system alignment, synchro bridge nulling, and transducer calibration. The module is available in two models. Model P-202 is a self contained resistance summing network for applications where test piece polarity precludes the use of a bridging transformer. The unit is also applicable where it is necessary to minimize in-phase ratio errors resulting from quadrature current flowing through reactive elements in null circuits. It is furnished in a range of resistances from 10,000 ohms to 1.0 megohm and with ac match between arms from 0.01 to 0.002 per cent. Arms are matched at 400 cps for total or combined effects of both real and reactive components. Power rating is 0.25 w.

Model P-201 is a reference isolation module which can be used on servo system alignment, where it is necessary to isolate the measurement reference channel from external circuits. It permits plug-in connection to any voltage measuring instrument using banana type receptacles. This module will accomodate signals from 1.25 to 150 v. It has an input impedance of 100,000 ohms. **Instrumention Div., North Atlantic Industries Inc.**, 603 Main St., Westbury, N. Y.

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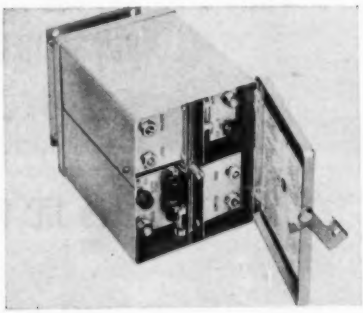


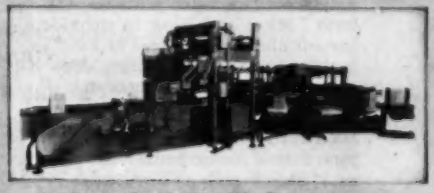
Electronic Alarm

Self-powered electronic alarm can actuate an annunciator or perform an auxiliary control function when a process signal reaches a preset point. Model R2A is a null-balance device suitable for one or two-point alarm, operating independently of the instrument circuit or in parallel with any of the company's indicator-recorder-controller combinations. The basic components for a single alarm-point are mounted on two printed circuit cards. Each unit has slots for two sets of these cards for high and low limit alarms. Conversion from one to

What?

Feed all these different sized cases, in random order, into one automatic case sealing installation?

Yes! It's being done. The Omnimatic-Rotopress automatically seals and discharges corrugated shipping containers of widely varying dimensions, fed to it in random order, at speeds up to 20 cases per minute. A choice of pre-set discharge patterns permits the simultaneous use of as many as five different Rotopress discharge stations, with sealed cases of different heights automatically discharged to separate take-away conveyors. The G. E. installation shown below, employing a unique circular compression unit, occupies only 144.9 square feet, and permits random feeding of cases that may vary in length from 8″ to 30″, in width from 6″ to 22″, and in height from 6″ to 18″. This machine can be built to accommodate your particular range of case sizes.



Packomatic Omnimatic-Rotopress operating at the General Electric Company's Trumbull Lamp Plant at Warren, Ohio.

WRITE for 8 page technical brochure giving complete design, application and dimension data. Request Packomatic Brochure 100-60.

Packomatic®

T.M. Reg. U. S. Pat. Off.

J. L. Ferguson Company
Box 1226 (Phone 6-6275)
Joliet 2, Illinois

Circle 719 on Page 19

two-point alarm or vice versa, is accomplished by adding or removing a set of printed circuit cards.

Alarm operates from a 0-0.5 v ac signal, compares the process signal with the adjustable alarm-point signal in a difference amplifier. When the process signal equals or exceeds the alarm point, the amplifier output reverses phase, and is fed through a phase-shifting network to the grid of a triode rectifier tube. It is compared with an ac reference signal continuously applied to the plate of the rectifier tube, energizing the load relay. When the phase of the grid-driving signal matches the reference signal, the tube stops conducting, and the relay is de-energized until the process signal is corrected. The normally-energized relay provides fail-safe action by de-energizing under conditions of tube or line power failure. **Swartwout Co.**, 18511 Euclid Ave., Cleveland 12, Ohio.

Circle 439 on Page 19

QUICK
FLUID LINE
CONNECTION
or
DISCONNECTION

with
INSTANT
AUTOMATIC FLOW
or
SHUT-OFF

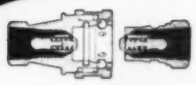
HANSEN
SERIES HK QUICK-CONNECTIVE
TWO-WAY SHUT-OFF
COUPLINGS

● Hydraulic and pneumatic lines are quickly and easily connected with Hansen Two-Way Shut-Off Couplings. No tools required.

When Coupling is disconnected, valves contact valve seats in both Socket and Plug to provide instant and positive seal of fluid in both ends of line. Coupling does not depend upon line pressure to seal either end of line.

Six sizes are available, with female pipe thread connections from 1/8" to 1" respectively. Furnished either in steel or brass.

Representatives in Principal Cities
... See Yellow Pages

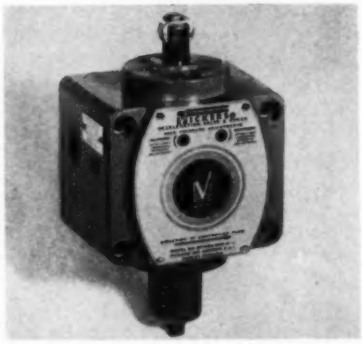


Instantly shuts off both sides of line... prevents loss of liquid, gas or pressure.

Quick-Connective Fluid Line Couplings for
COMPRESSED AIR • OIL
GREASE • HYDRAULIC FLUIDS
WATER • VACUUM • STEAM
OXYGEN • ACETYLENE
REFRIGERANTS • GASOLINE
COOLANTS • LP-GAS

Write for the Hansen Catalog
Here is an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings.

SINCE 1915 — QUICK-CONNECTIVE FLUID LINE COUPLINGS
THE HANSEN MANUFACTURING COMPANY
4031 WEST 150th STREET • CLEVELAND 35, OHIO



Deceleration Valve

Deceleration valve for hydraulically operated machinery features a throttle which permits external adjustment of back pressure to provide the desired deceleration rate. Valve is rated at 5 to 25 gpm nominal flow, but it can also be used for applications up to 60 gpm without malfunction. Maximum recommended operating pressure is 3000 psi. An internal port area is altered by the external adjustment to provide proper deceleration characteristics through the complete flow range. The spool stroke length remains constant regardless of the volume setting. An adjustable needle valve permits metering oil through the valve when complete shut-off is not desired. **Vickers Inc., Div., Sperry Rand Corp.**, 1400 Oakman Blvd., Detroit 32, Mich.

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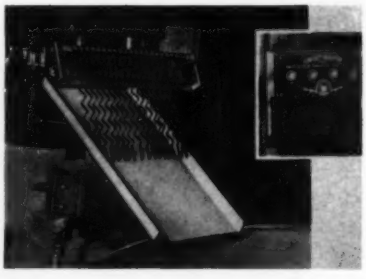
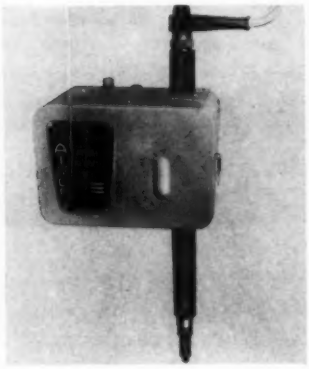


Parts Detector

Suitable for use on presses with speeds up to 150 spm, device protects dies from overloads by stopping machines when parts are not ejected on schedule. In operation, when properly ejected small parts strike against the multiple feelers of the assembly, they break a magnetic contact and send the required impulse to a missing parts detector

control unit. If the impulse is not received by the control unit, electronic circuits automatically signal the emergency stop circuit, preventing the machine from striking again. Thus, the unejected part cannot cause a die-damaging overload. Gravity plus magnetic pull return the feelers to normal position after each stroke. **Wintriss Inc.**, 20 Vandam St., New York 13, N. Y.

Circle 441 on Page 19



Welding Unit

Automatic welding unit is applicable on ferrous and nonferrous metals where a good weld appearance is necessary or where stringent specifications must be met. It is electronically controlled and can be used for either ac or dc welding, without an accessory control, using argon, helium, or mixtures of these shielding gases as required. The unit can be operated at a maximum of 500 amp continuous duty cycle, dc straight polarity using thoriated tungsten electrodes, or 350 amp ac. Electrode diameters from 0.010 through 3/16 inch can be used. Unit can be rotated 360 degrees with a 2-inch adjustment of the machine holder across the weld bead; head can be moved vertically a distance of 14½ inches. Holders have a maximum vertical rate of rise of 24 ipm. Two styles are available (Models HMH-D and HMH-E). Model HMH-D is equipped with 3 and 12-inch offset bars to which the machine holder can be attached. **Air Reduction Sales Co., Div., Air Reduction Co. Inc.**, 150 E. 42nd St., New York 17, N. Y.

Circle 442 on Page 19

RANSBURG

What Would Paint Savings Like This* Mean in YOUR Finishing Department?

Quality is all important in the production of fine Metalcraft furniture by George Koch Sons, Inc., Evansville, Indiana.

That's why they use the Ransburg Electrostatic Hand Gun to apply a uniform clear coating on their brass-plated furniture. The protective coating is baked on. Although the bulk of their present production is in the popular brass line, they still paint the metal furniture in a variety of colors with the Hand Gun.

Painting is CLEANER ... QUICKER ... CHEAPER *with the Ransburg Electrostatic Hand Gun.*

These chairs and table are typical of the Koch line of metal furniture.

***10 GALLONS OF PAINT NOW DOES THE JOB WHICH FORMERLY TOOK 30 GALLONS**

On one item—a TV table—they formerly used 30 gallons of enamel to coat 1000 units by combination dip and air spray method. Now—with the Ransburg Electrostatic Hand Gun, they paint 1000 tables with only 10 gallons. And, they get a better, more uniform coating, too.

NO REASON WHY YOU CAN'T DO IT, TOO!

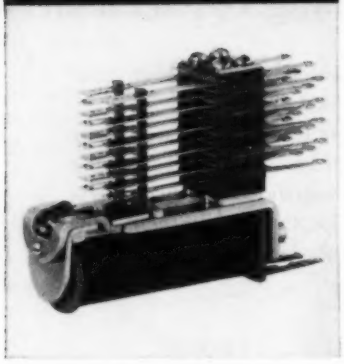
See how the Electrostatic Hand Gun can save time ... paint ... and cut costs in YOUR finishing department. Or, if your production justifies, it'll pay you to investigate Ransburg's automatic electrostatic spray painting equipment. Write for our No. 2 Process brochures which show numerous examples of modern production painting in both large and small plants.

RANSBURG

RANSBURG
Electro-Coating Corp.
Box-23122, Indianapolis 23, Indiana

Circle 721 on Page 19

"Telephone Quality"
Stromberg-Carlson
RELAYS



...to meet your electromechanical switching needs

These are the very same twin-contact relays proven outstandingly successful through many years of precise, exacting operation in the telephone industry.

The following regular types are representative of our complete line:

Type A: a general-purpose relay with up to 20 Form "A" spring combinations.

Type B: a gang-type relay with up to 60 Form "A" spring combinations.

Type BB: accommodates up to 100 Form "A" spring combinations.

Type C: two relays on the same frame. A must where space is at a premium.

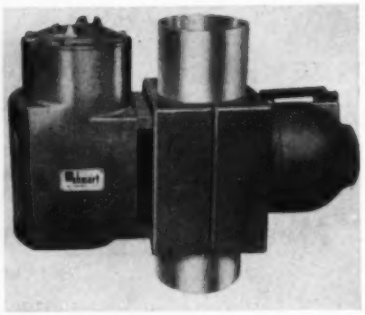
Type E: same characteristics as the Type A, plus universal mounting arrangement. Interchangeable with many other makes.

Types A, B and E are available in high-voltage models (insulation withstands 1500 volts A.C.) for test equipment and other high-voltage applications.

Details and specifications are in our complete relay catalog, available on request. Write to Telecommunication Industrial Sales.

STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS
111 Carlson Road • Rochester 3, N. Y.

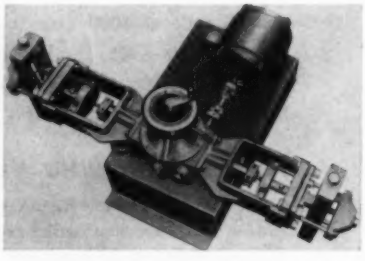
Circle 722 on Page 19



Density Measuring Gage

Designed to automatically measure the specific gravity or per cent solids of liquids flowing through processing lines, density gage can be used on pipes through 8 inches in diameter. A source of radioactive material is mounted in a safety shielded holder on one side of the line and a measuring cell is on the other side of the line. The cell detects radiation energy in proportion to the density of the material flowing past the gage and changes the sensing into an electrical signal which is amplified and fed to a recorder or controller for actuating pumps or valves. Since it does not contact the material being measured, the gage is suitable for use in hazardous locations. Two units are available. Model PG uses electrical zero suppression and Model PGV uses a compensating cell for long term stability. The gages measure spans as narrow as 0.15 specific gravity units with a precision as narrow as 0.0015 units. **Ohmart Corp.**, 2236 Bogen St., Cincinnati 22, Ohio.

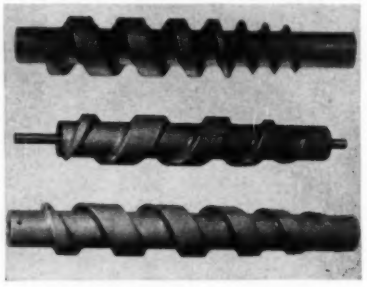
Circle 443 on Page 19



Metering Pump

Line of positive displacement, reciprocating, plunger type metering pumps has capacities ranging from 0.65 to 2025 gph. They have a metering accuracy within ±1 per cent and will operate against pressures up to 4000 psi. The pump drive is designed to function with one, two, or three liquid ends. The liquid ends can be changed as complete units for different capacities or liquids. For blending 2 or more liquids, a number of simplex, duplex, or triplex units can be coupled to the drive shaft. One model of the pumps in the 200 Series can be adjusted for stroke length and feed rate while the pump is running. **Wallace & Tiernan Inc.**, 25 Main St., Belleville 9, N. J.

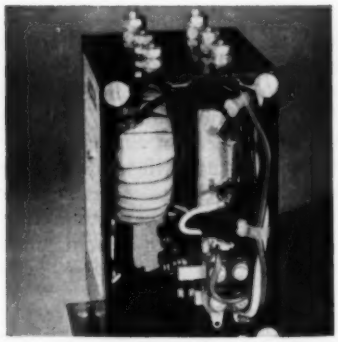
Circle 444 on Page 19



Timing Screws

Timing screws can accurately feed round, oval, square, or rectangular glass bottles, metal cans, or plastic containers on packaging machines such as fillers, cappers, labelers, washers, and tablet counters. The screws will pick up containers from a conveyor at random, move them under controlled acceleration and speed and discharge each container at the required spacing for the packaging operation. The units can also be used as line dividers for line synchronization. Each timing screw is generated to fit a specific container or range of container diameters, as well as the machine pitch requirements. If desired, a two-point contact can be maintained between the screw and the container to provide stability for tall items. The screws are made of non-marking, resin-impregnated linen or cellulose material. They are driven by the normal power takeoff from the packaging machine drive to assure synchronization with the operation being performed. **Arthur Colton Co.**, 3400 E. Lafayette, Detroit 7, Mich.

Circle 445 on Page 19



Midget Relay

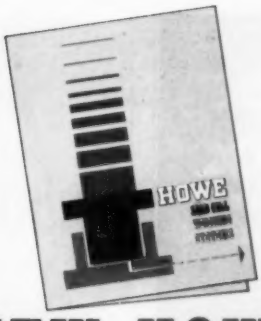
Mechanically held midget relay is a compact unit suitable for hermetic sealing or machine tool applications. It is rated for 5 amp at 250 v maximum for all classes of load or 1 hp at 250 v ac, 3ϕ. Relay is constructed with a single coil and a rotary solenoid operator. Contact forms are 4 pole normally-open, 4 pole normally-closed, with double break, self-aligning silver alloy contacts. **Automatic Switch Co.**, Florham Park, N. J.

Circle 446 on Page 19

Hydraulic Filter

Hydraulic, in-line filter can be used on either the pressure or suction side of a pump. With a choice of how the filter is used, it can be mounted so that the filter element is readily accessible for cleaning or replacement without disassembly and reassembly of a piping system or the draining of a sump tank. This simplifies the maintenance of the hydraulic system. Filter is constructed with three ports, two *In* and one *Out*. Maximum operating pressure of the unit is 150 psig. **Arrow Tools Inc.**, 1972 S. Kostner Ave., Chicago 23, Ill.

Circle 447 on Page 19



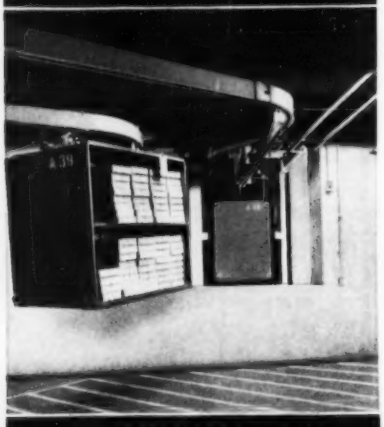
NEW HOWE LOAD CELL WEIGHING SYSTEMS FOLDER

Here's complete information on the latest in load cell weighing systems for heavy duty installations—how it works, advantages, applications, components, instruments and accessories. Write today for your free copy.

Circle 723 on Page 19

Power -Flex

POWER AND FREE
OVERHEAD CONVEYOR SYSTEM*



WITH TELEMATIC
AUTOMATIC DISPATCH CONTROL

• *Simply set dials and Telematic guides carrier to any station in system*

Employs exclusive unitized "over and under" power and free rail which permits simple switching to right or left as desired.

Power-Flex is designed for automated materials forwarding applications in industrial plants, distribution centers, service buildings and department stores. The most economical system available for loads up to 600 lbs. per carrier. Savings in actual installations range from 25% to 60%.

*Systems in service for your inspection.

Engineered to your very specific requirements.

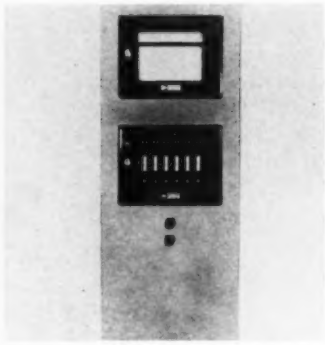
SEND FOR BROCHURE

Inquiries from your engineers or consultants welcomed.

CM CONVEYORS

COLUMBUS McKINNON CHAIN CORPORATION
Conveyor Division
TONAWANDA, N. Y.

Circle 724 on Page 19



Recorder-Controller

Combination recorder-controller can control up to six points and record up to 24 points. Instrument can operate from either one or two separate thermocouples or other inputs per point. Using two inputs provides protection against failure of either half of the system. Both *On - Off* and proportional electric control are available. Pneumatic control can be supplied by the use of electropneumatic converters. **Daystrom-Weston Industrial Div., Daystrom Inc.**, 614 Frelinghuysen Ave., Newark 12, N. J.

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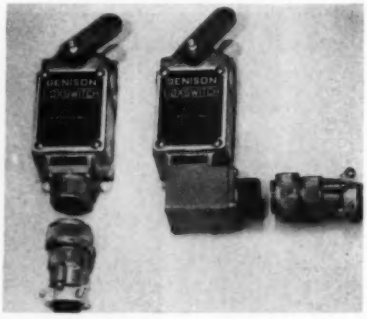
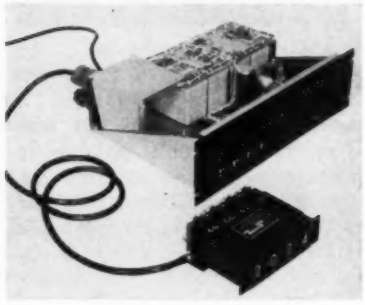


Plug-In Limit Switch

Heavy duty machine tool limit switch features a completely sealed plug-in electrical connection. Model PL100W is furnished with a male receptacle unit mounted on, and wired directly to the switch. The male receptacle is permanently attached to the switch so it cannot be accidentally unscrewed and break the water-tight seal or damage the wiring. The cord half of the switch is a precision built female plug and screw collar for quick attachment to the switch with a four foot length of machine tool cable. The cable and plug are wired and epoxy sealed and held together with a mechanical clamp. When assembled, the two units provide a strong, sealed connection between the cable and the switch. A model with right-angle attachment of cord is available. **R. B. Denison Mfg. Co.**, 386 Broadway, Bedford, Ohio.

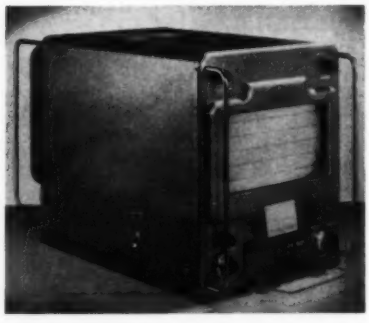
Circle 449 on Page 19



Digital Clock

Applicable in data logging, programming, or computer operations, digital clock has sealed components and can be used in hazardous locations. Features of the clock include: Oil filled step switches, mercury wetted relays, and sealed switches. The visual display is composed of single plane in-line lamp banks which can be remotely mounted. Clock is reset by pushbutton reset switches. Digital output contacts are available in either decimal or binary coded decimal form. **Parabam Inc.**, 13000 Yukon Ave., Hawthorne, Calif.

Circle 450 on Page 19



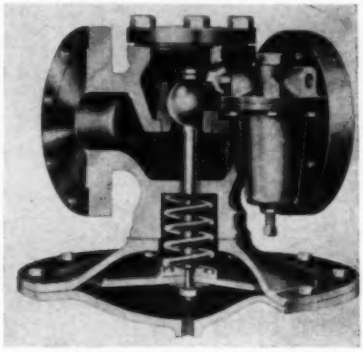
Flaw Detector

Ultrasonic unit, designated Reflectoscope, is suitable for both contact and immersed inspection. It

can be mounted directly on scanning bridges now in use. Features of the instrument include: A 12-inch dual trace display tube, a two-color display that distinguishes flaw indications from range marks, and four fast-acting flaw gates with separate channel indication for signaling the presence of flaws or reduction of back reflection.

Double slope distance amplitude correction controls compensate for both near field effects and attenuation in the material. Frequency ranges of the detector run from 1.0 to 25.0 megacycles. The calibrating circuit shows the action of the distance amplitude correction curve on the screen. The repetition rate is variable from 200 to 2000 pps. **Sperry Products Inc.**, Shelter Rock Road, Danbury, Conn.

Circle 451 on Page 19



Pressure Reducing Valve

Pilot operated steam pressure reducing valve is constructed with a stainless steel ball inner valve which closes against a monel seat ring. The tapered form of the opening between the ball inner valve and beveled seat ring increases the valve capacity by streamlining the flow of steam. The large main valve diaphragm is made of stainless steel to permit use with higher pressures and temperatures. The control spring is located outside the path of steam flow. Model KP-4 is available in sizes from ¾ to 4 inches, in either a bronze, semisteel, or cast steel body. Screwed ends are furnished in sizes up to 3 inches. Flanged bodies are furnished in sizes from 1¼ to 4 inches. **Klipfel Valves Inc.**, 1075 Lincoln Ave., Hamilton, Ohio.

Circle 452 on Page 19

Announcing . . .

New Production Capacity

To Serve You Better

Large Generated Gears

SPUR—HERRINGBONE—HELICAL

for a wide range of industrial applications

Gears which must operate smoothly and without vibration at higher speeds and under greater loads must correspondingly be more accurate in tooth profile and spacing.

H & S Generated Gears provide these results.

To meet increasing customer demands, Horsburgh & Scott has broadened its manufacturing capacity and tooled to produce *large* Generated Gears up to 125" diameter.

Offering the same high quality standards which characterize the complete H & S Gear line, production capacities for large Spur, Helical and Hobbed-Herringbone Gears are now available in the following dimensions:

Up to 80" outside diameter at 1 DP
Up to 90" outside diameter at 1¼ DP
Up to 100" outside diameter at 1½ DP
Up to 125" outside diameter at 2 DP

Face widths up to 42", depending on helix angle.

Take advantage of this new capacity, and our long experience as specialists in this field. Send your specifications, drawings or plans — or tell us about your power transmission problem. Our technical staff will promptly consider your requirements and render recommendations and quotations.

THE HORSBURGH & SCOTT CO.

GEARS AND SPEED REDUCERS

5112 Hamilton Avenue • Cleveland 14, Ohio

Circle 725 on Page 19

Process Controller

Transistorized digital instrument is suitable for bidirectional measurement and control applications such as automatic machine or material positioning, measuring or cutting-to-length, coil winding, and pulse tachometry. It provides a direct-reading numerical display of the measurement and has provisions to actuate various control functions on production equipment when a preset number is reached.

In operation, in an automatic positioning application for cutting material to length, the numerical value of any desired position or length is preset on the controller panel. A motorized positioning device is controlled to automatically stop motion of material when this number is reached. An add-subtract bidirectional transducer senses the changes in overall length as each piece is cut off. The transducer converts the measurement into digital voltage pulses which are fed to the controller and are automatically subtracted from a total quantity. The controller accepts input pulses from two lines—one for addition, and one for subtraction. It operates at rates up to 20,000 counts per second and higher. The positive and negative counts are displayed on the panel by either illuminated numerical tubes or flow counter tube decades. **Dynapar Corp.**, 7312 N. Ridgeway Ave., Skokie, Ill.

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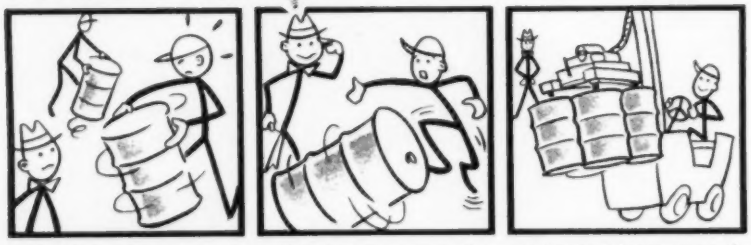
VAC-U-LIFT VAN Solves another Material Handling Problem!



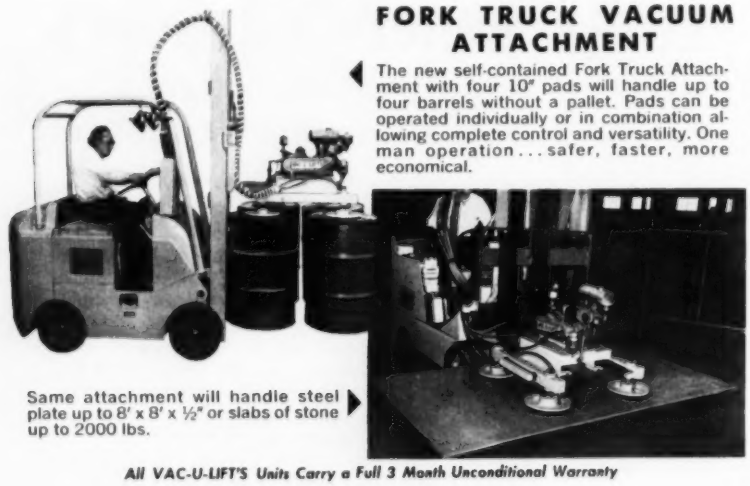
1 Boy! Oh Boy! these fellows are sure handling these cumbersome heavy steel drums the hard way.

2 This looks like a case of an accident just waiting to happen. We've solved problems like this before though. Wait until I tell them about our Fork Truck Attachment.

3 Look at them go now! One man does the job safer and more economical than three or four men could the old fashion way.

FORK TRUCK VACUUM ATTACHMENT

The new self-contained Fork Truck Attachment with four 10" pads will handle up to four barrels without a pallet. Pads can be operated individually or in combination allowing complete control and versatility. One man operation ... safer, faster, more economical.



Same attachment will handle steel plate up to 8' x 8' x ½" or slabs of stone up to 2000 lbs.

All VAC-U-LIFT'S Units Carry a Full 3 Month Unconditional Warranty

VAC-U-LIFT

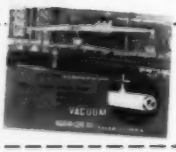
HAS THE SOLUTION!

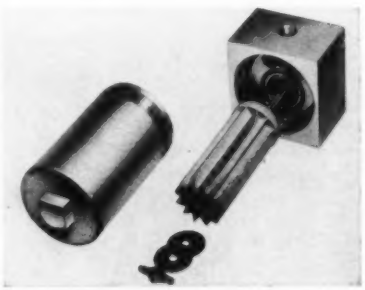
Send Today For FREE Illustrated Brochure

This brochure shows some of the many VAC-U-LIFT systems now in use. It explains how VAC-U-LIFT works and how you can take advantage of VAC-U-LIFT'S 3-step analyzation service without cost or obligation, write

DEPT. VL-94, VAC-U-LIFT CO., Salem, Illinois

Division of the Siegler Corporation





Fluid Filter

Designed for use with petroleum, ester, or glycol based hydraulic fluids, silicones, water, and air, unit features a reinforced sintered 40 mu filter element that can be cleaned by washing in a solvent and reverse blowing with air. It is contained in a forged aluminum bowl threaded to an extruded aluminum head. The bowl can be removed from the head and the filter element cleaned without disturbing piping connections. The entire unit is rated at 1000 psi operating pressure. It is constructed so that an accumulation of foreign matter causing a pressure drop of as much as 400 psi across the element will not cause the element to disintegrate. At pressure drops higher than 400 psi, the element may crack, but downstream components are protected from particles and small pieces of the element. **GPE Controls Inc.**, 240 E. Ontario St., Chicago 11, Ill.

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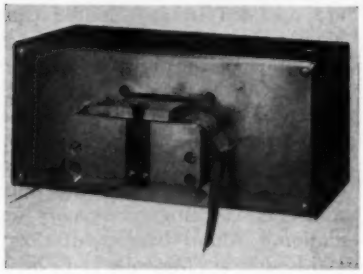
PUNCHED TAPE BLOCK READER



A versatile input device for numerically controlled systems

TAPE:	Standard 1 inch 5, 6, 7 or 8 levels, paper or Mylar.
CAPACITY:	Up to 30 lines per reading (240 bits.)
SPEED:	Up to 10 frames per second.
OUTPUT:	Triple wire brush contacts, rated at 50V and 50mA non-inductive.
PERFORMANCE:	Tested for 500,000 readings without error.
PRICE:	$1200. (12-line reader).

WANG LABORATORIES, INC.

12 Huron Drive • Natick, Massachusetts

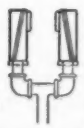
OLympic 3-3910

Circle 727 on Page 19

Photoelectric Controls for every purpose

Remote Heads for Small Spaces

E8A-E8AP Remote heads with special mounting bracket



E1A-E1AP

Compact, rugged—easily positioned remote heads. Available with ¼" diameter straight beam—also fixed focus pin point beam.

Heavy Duty Industrial Construction.

for tension, jam-up, counting, registration, illumination, liquid and material level — sorting, measuring, weighing, inspection, die-protection, smoke detection, packaging, processing, marking.

Wide selection of standard controls and light sources to meet all kinds of uses.

Send for Catalog or tell us what you want to do.

AUTOTRON, INC.

Box 722 Danville, Ill.

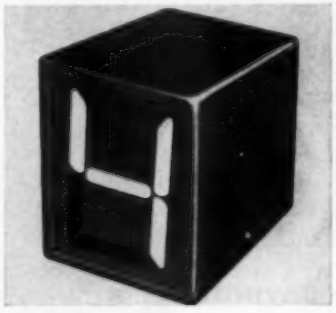
Representatives in principal cities

Circle 728 on Page 19

Display Oscillograph

Bar graph instrument provides an accurate, visual display of any data that can be measured by an electrical output, such as temperature, pressure, strain, and velocity. It has accommodations for as many as 90 inputs and can display one of the inputs or any combination having comparable electrical outputs. Sensitivity for Model 201 is from 0-10 mv full scale to 0-150 v full scale. Full scale deflection is 15 cm, accuracy is ±2 per cent of full scale, resolution is 40 lines per inch. An alarm is provided on any input exceeding a given percentage of full scale input. The alarm dial is calibrated 0-110 per cent full scale. **Advanced Technology Laboratories, Div., American - Standard,** 369 Whisman Rd., Mountain View, Calif.

Circle 455 on Page 19



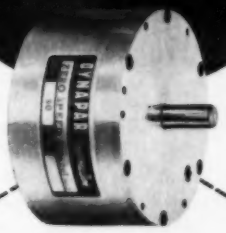
Readout Module

Digital readout module operates on electromagnetic principles, is applicable for instrument displays and data presentation. The module can be energized as required to display

NEW

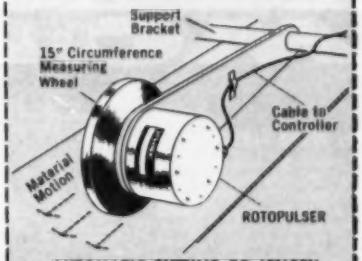
DYNAPAR ZERO-SPEED ROTOPULSERS

for precise industrial measurements and AUTOMATION control



• Rugged, heavy duty sensing units • Provide up to 2400 pulses per rotation • Extremely compact • Highly resistant to vibration • Wide temperature range • For continuous duty applications

DYNAPAR *ROTOPULSERS* MEASURE: RPM . . . LENGTH . . . BELT SPEED . . . METAL ELONGATION . . . PAPER DRAW . . . SPEED RATIOS . . . POSITION (using new Add-Subtract *ROTOPULSER*).*



AUTOMATIC CUTTING TO LENGTH

ROTOPULSER connected to measuring wheel converts length into pulses. Remote controller counts pulses and actuates power shear when predetermined length is reached. Accuracy: to 5/1000th inch—at any speed!

Dynapar ROTOPULSERS are rotary sensing devices which convert all kinds of MOTION into shaft rotations, and then into digital voltage PULSES. These pulses are fed to remote digital readout or control devices for: *counting . . . numerical readout . . .* and *actuation of automatic control functions* on industrial equipment at any preset count. SEND FOR NEW ROTOPULSER BULLETIN #14B.

**Send for Application Data Sheets describing ROTOPULSERS in these and other industrial applications. Please give details about your measurement-control problem.*

DYNAPAR corporation

TRANSISTORIZED PROCESS CONTROLLERS • DIGITAL AUTOMATION CONTROLS • TACHOMETERS

Circle 729 on Page 19

Step-up Production Line EFFICIENCY

Systems are available with speed reducing or increasing gears—with 12- or 24-hour disc charts or with 31-day strip-type charts.

with

Wagner-Sangamo industrial Tachographs

Use these precision recording devices anywhere that the control of speed, time and measurement is essential to the quality of your products. They tell you how fast and long a machine is used . . . let you measure output versus time . . . fit in perfectly with quality control and time study programs . . . graphically record operation of one machine or entire automated line to help you determine production peaks and valleys, and non-productive time.

Consult your nearby Wagner Sales Engineer, or write us about your production recording problem. Wagner engineers will tell you if Tachographs will help you increase production efficiency.

W160-1

Wagner Electric Corporation

6430 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

Circle 730 on Page 19

MOLINE

No. HD68 Special

Multiple-Spindle Machine with 81" clearance between columns, drills, reams and chamfers holes in tube sheets of various sizes. Electric control provides means for determining hole pattern through selection of in-line spindles and control of two-way, positive-positioned hydraulic indexing work table.

For Greater

PRODUCTION • EFFICIENCY • SAVINGS

Use an individually designed "Hole-Hog" Machine Tool for such jobs as:

- Multi-Spindle Boring
- Single and Multi-Spindle Honing
- Straight Line Multi-Drilling
- Adjustable Spindle Drilling
- Vertical and Way-Type Fixed Center Drilling, Boring and Tapping
- Special Multiple Operation Machine Tools

Over 55 years of Machine Tool Engineering experience is at your service. Tell us your particular problem.

MOLINE TOOL CO. HOLE-HOG MOLINE, ILLINOIS

MOLINE TOOL COMPANY

100 20TH STREET • MOLINE, ILLINOIS

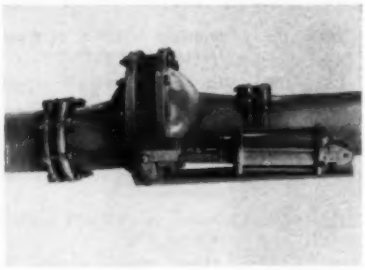
REPRESENTATIVES IN PRINCIPAL CITIES

107

Circle 731 on Page 19

any numeral from 0 through 9. In-plane digital display is accomplished by using seven miniature electromagnetic indicating segments that are operated in any desired combination by a low power dc signal. Operation of the unit can be from any dc voltage from 1 to 30 v, with response time less than 0.1 second. Two types of modules are available —Model 201 is for momentary operation and Model 202 is for pulse controlled latching or memory operation. **Allard Instrument Corp.**, 146 E. 2nd St., Mineola, L. I., N. Y.

Circle 456 on Page 19



Special Valve

Capable of handling abrasive slurries, valve can be installed in any position, has no slots or guides to interfere with the valve movement. Designed for a working pressure of 150 psi, it can be operated remotely with an air or hydraulic cylinder. The valve is self-draining, therefore there are no pockets for water to accumulate and freeze. It is available in five sizes from 4 to 10 inches. Body of the valve is constructed of wear resisting alloy and the valve disc is made of aluminum bronze, with the valve stem of stainless steel to resist corrosion. **United Conveyor Corp.**, 6505 N. Ridge Blvd., Chicago 26, Ill.

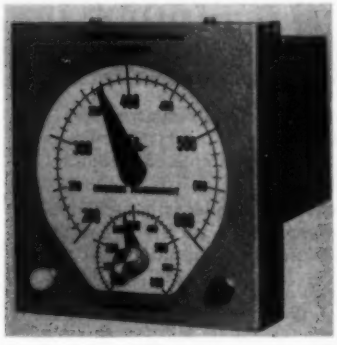
Circle 457 on Page 19

Electric Vibrator

Applicable to the flow of materials from bins and hoppers for chemical plants, food packaging, and concrete molds, electric vibrator has a mounting aspect which puts the vibrational orbit close to and parallel with the hopper wall, eliminating the need for a reinforcing plate on thin hopper materials. Model DHE-111, designated Motomag-

netic, has a stepless speed control from 2000 to 10,000 vpm, while operating. Unit operates on 115 v, ac or dc, and has forced air cooling. **Martin Engineering Co.**, Neponset, Ill.

Circle 458 on Page 19



Temperature Controller

Instrument controls temperature electronically without depending on the meter movement for control. It has a 12-inch circular readout based on a stable null balance servo system, presents a true indication of the process being controlled throughout the entire range of the instrument without limiting stops. The instrument, designated the 6000 series, is available with either time proportioning or on-off control, with or without anticipating action. Control stability of the proportional model with anticipation has been achieved to ±0.1 F, and to ±0.5 F with the on-off model with anticipation. Indication accuracy is ±1 per cent of scale range. **Electronic Processes Corp. of Calif.**, 436 Bryant St., San Francisco 7, Calif.

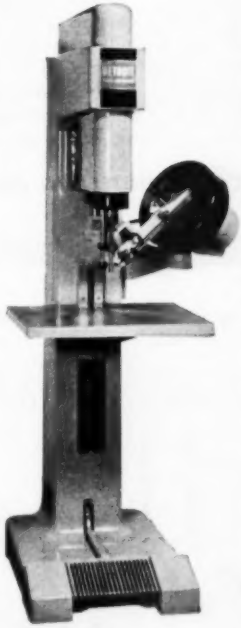
Circle 459 on Page 19

How many what's your guess?

Screws are #8-32 x ½ inch long.

One man can drive them in one hour

with a DPS power screwdriving machine



The new DPS Model U screwdriving machine.

Why sacrifice manpower on so simple yet tedious a job as driving screws? Free skilled hands for more productive work . . . get higher output per happier manhour—with a DPS power screwdriving machine.

To illustrate, one worker can drive the 2,400 screws in the jar above in one hour. And with no more effort than pressing an air-operated foot pedal. Equally important, they're driven through an easily adjustable clutch, designed to hold constant driving torques.

NEW! THE MODEL "U"—At left, meet the great, new DPS Model "U" screwdriving machine—quickly adaptable for fast, clean driving of screws, nuts and studs. New folder contains full data. Write for your copy today.

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A Subsidiary of Link-Belt Company

Circle 732 on Page 19

NEW!

SCHRADER INDUSTRY-INTERCHANGEABLE HI-FLO* AIRLINE COUPLER!

SAFE PUSH-PULL OPERATION
ACCIDENTAL UNCOUPLING NO LONGER A PROBLEM!

Schrader's new quick-acting couplers are full of features that afford the best air service. Safety's built in . . . it won't open accidentally even when dragged on the ground and snarled on a piece of machinery . . . yet the heavily knurled new coupler connects and disconnects in a single upstream push or pull with *one hand, gloved or greasy!*

More features: fastest air flow . . . non-corrosive . . . case hardened steel all through . . . meets and exceeds military specs . . . engineered for simple, easy replacement of parts in the field.

Important: Schrader's new coupler is interchangeable with others of similar type. A variety of end fitting styles are available. See your supplier soon.

NEW COUPLER CHECK UNITS AND ADAPTERS

#5139-12—¼ N.P. FEMALE

#5138-12—¼ N.P. MALE
#5140-12—⅜ N.P. MALE

#5138-11—¼ N.P. MALE

#5139-11—¼ N.P. FEMALE

#5140-11—SERRATED SHANK FOR ⅜ I.D. HOSE

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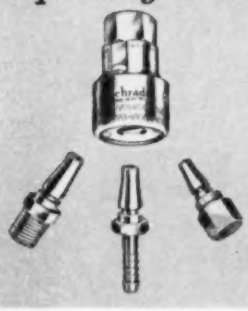
SCHRADER HOSE REELS work like window shades. Tuck hose away automatically. No. 3481 is Air Tool Suspension Type.

SCHRADER LUB-AIR-ATOR does 3-way job: filters, lubricates, regulates. Keeps systems operating smoothly.



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SCHRADER LEVER TYPE BLOW GUN offers precision control, from a gentle puff to a full blast.

SCHRADER BUTTON TYPE BLOW GUN is all-purpose, easy-operating, with durable forged brass body.

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QUALITY AIR CONTROL PRODUCTS

Circle 733 on Page 19

AUTOMATION

catalogs and literature

Latest automation information. For copies use card on page 19.

Contact Modulator

Cambridge Div., Airpax Electronics Inc., Cambridge, Md.—6 booklets—Technical series consists of six booklets on the contact modulator. First booklet discusses why choppers are necessary and the type employed in various applications; the second booklet gives details on the measurement of chopper parameters and the test equipment used in measurement. Succeeding booklets cover modulation methods and practical modulator circuits, analyses of capacity and transformer-coupled modulators, chopper amplifier design, and frequency response in chopper amplifiers, and chopper amplifier circuitry.

Circle 460 on Page 19

Air Control Valves

Hunt Valve Co., Salem, Ohio—12 page booklet—Details are given in Bulletin 592 on the Trim Line subminiature valves which are suitable for controlling small cylinders or operating diaphragms and pilot cylinders. Cutaway drawings show the six different valve actions—palm button operated, lever operated, ball actuated, pilot operated spring return, double pilot operated, and pilot operated bucking return. J.I.C. diagrams of each valve are also given.

Circle 461 on Page 19

Pulse Code Telemetering System

Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif.—12 page booklet—Applications of the pulse code telemetering system for the remote indication of liquid level, temperature, pd meters, pressure gages, and control device indicators are discussed in Bulletin CP 3707. The basic pulse code system is explained, aided by a schematic drawing. Notes are also included on data gathering, reduction, alarm, and control functions.

Circle 462 on Page 19

Air-Hydraulic Speed Presses

Studebaker Hydraulic Products Co., 1733 N. 33rd St., Melrose Park, Ill.—8 page bulletin—Four styles of air-hydraulic speed presses are described in Bulletin AH-98, ranging in capacities from 1½ to 10 tons at 80 lb air supply. Sequence of press operation is explained, and features of the press are covered. Notes are also given on optional equipment such as time relay control, ram speed control valve, and adjustable positive mechanical down stop control.

Circle 463 on Page 19

Controlled Feeding Equipment

Jeffrey Mfg. Co., 956 N. 4th St., Columbus 16, Ohio—48 page catalog—Line of equipment for weighing, batching, and proportioning systems is outlined in Catalog 941. Data are given on six types of constant weight feeders, on vibrating conveyors, coolers and dryers, controls, magnetic separators, vibrating screens, tubular feeders, barrel packers, and bin valves. Application photos and specification drawings are included.

Circle 464 on Page 19

Miniature Pulse Transformers

PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif.—18 page booklet—Booklet entitled "The Design and Usage of Miniature Pulse Transformers" covers the history of low-level pulse transformers. The differences from other transformer types are discussed, as are the methods of measurement and theory of application. Other reports are given on pulse transformer equivalent circuits, transformer polarization, methods of degaussing a core, manufacturing procedures, style and packaging. Also included are circuit diagrams and pulse width charts.

Circle 465 on Page 19

Magnetic Disc Brakes

Dings Brakes Inc., 4740 W. Electric Ave., Milwaukee 46, Wis.—8 page bulletin—Line of direct-acting magnetic disc brakes is described in Bulletin BK-4005. Data are also given on self-adjusting brakes and hazardous location brakes. Formulas based on torque and thermal capacity are given to help determine the selection of the most efficient brake for a specific purpose. Features such as the fail-safe design, automatic reset manual release, and direct-acting operation are explained.

Circle 466 on Page 19

Flame-Cutting Machine

Air Reduction Sales Co., Div., Air Reduction Co. Inc., 150 E. 42nd St., New York 17, N. Y.—8 page bulletin—An eight-foot flame-cutting machine, designated Linagraph, is the subject of Bulletin ADC-899. The machine can automatically and simultaneously cut four identical pieces from a single template. Photos show the operation of the automatic gas-cutting machine and its adaptability to various tracing devices. Details are given on the design and construction features.

Circle 467 on Page 19

Checkweight Scales

Thayer Scale Corp., 1 Thayer Park, Pembroke, Mass.—4 page pamphlet—Data are given on three models of the Series CF checkweight scales which are designed for continuous weighing of bags, boxes, drums, and packaged goods. Operation of the unit is explained, and specifications and outline dimensions are listed. Notes are also given on optional equipment such as a recorder, indicator, counter, and sweep arm reject.

Circle 468 on Page 19

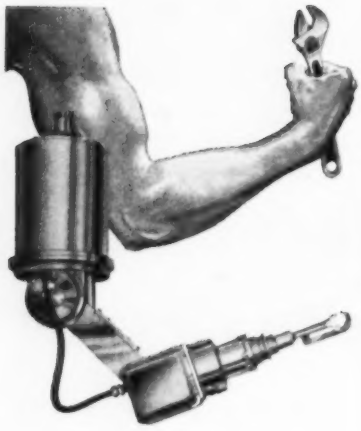
Cam-Operated Indexing Units

Standard Tool & Mfg. Co., Kearny, N. J.—4 page pamphlet—Cam-operated indexing units for automatic industrial positioning and conveyor control are outlined in Bulletin 12C. The units can provide positioning for mechanical operations such as soldering, crimping, milling, drilling, and assembly. Engineering data for two models are given; one has a production rate of 50 to 90 units per minute, the other has a production rate of 10 to 45 units per minute.

Circle 469 on Page 19

Electronic Air Cleaner

Dollinger Corp., Rochester 3, N. Y.—12 page booklet—Subject of Bulletin 405 is an electronic air cleaner which eliminates smoke, airborne dust, and pollen in all types of ventilating systems. Details are given on components in the cleaner such as the ionizer collector cell, power supply unit, and air filter. The two types of washing systems are also described—a horizontal header with attached nozzles



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General Mills

Circle 734 on Page 19

permanently fastened to the front of the filter bank and a timer controlled solenoid valve and adhesive pump which supplies cold water and adhesive to separate headers.

Circle 470 on Page 19

Solenoid Valves

Automatic Switch Co., Florham Park, N. J.—16 page booklet—Solenoid valve stock list and selection guide (Bulletin 506) contains data on 2-way valves for pressures up to 1500 psi, 3-way valves for pressures up to 600 psi, 4-way valves for pressures up to 500 psi, and 2 and 3-way manual reset valves for pressures up to 250 psi. Special purpose valves and accessories are also covered. Diagrams show construction and flow arrangement.

Circle 471 on Page 19

Automatic Profiler

Pratt & Whitney Co. Inc., Charter Oak Boulevard, West Hartford 1, Conn.—8 page bulletin—Subject of Bulletin 635 is MagneTrace, a tracer-controlled milling machine designed for self-feeding 360 degree profile milling operations under tracer control. Details are given on the three elements that make up the closed-loop control system. Photos show the design and construction features, and notes are also given on the safety features.

Circle 472 on Page 19

Transmitting Rotameters

Instrument Div., Schutte & Koerting Co., Dept. MQ, Cornwells Heights, Bucks County, Pa.—4 page pamphlet—Data are contained in Bulletin 18N on pneumatic transmitting rotameters which can be used for communicating rotameter-measured fluid rates of flow to indicators, recorders, controllers, and integrators. Construction features of the instrument and characteristics of the transmitter unit are given, and a schematic diagram shows the principal components of the transmitter.

Circle 473 on Page 19

Automatic Weighing & Handling

Farrel-Birmingham Co., Inc., Ansonia, Conn.—4 page pamphlet—Pamphlet A58-DM24 describes a typical small plant setup for automatic weighing and charging of batch ingredients into a single mixer. System development is discussed, and a schematic drawing shows the layout of a system. Installation photos are also included.

Circle 474 on Page 19

Motor Controls

Furnas Electric Co., 1128 McKee St., Batavia, Ill.—72 page catalog—Catalog 5900 outlines motor controls such as manual starters, magnetic starters, drum controllers, pressure switches, and various pilot devices. Some of the products featured in the catalog include: Manual starters, Size 0 to 1¾ nonreversing and reversing starters, and Size 5 and 6 magnetic starters and contactors. Also included are selector charts for magnetic and manual starters which list horsepower, motor speed, heater size, heater ampere ratings, and enclosure choices.

Circle 475 on Page 19

Drum Filter

Eimco Corp., P. O. Box 300, Salt Lake City 10, Utah—12 page booklet—Continuous belt drum filter for liquid-solids separation is described in Bulletin F-2053. Details are given on the operating principle which employs a filter medium that is removed from the drum every filter cycle. Photos show the step-by-step procedure in changing a cloth on the filter.

Circle 476 on Page 19

Photoelectric Controls

General Electric Co., Schenectady 5, N. Y.—16 page booklet—Line of photoelectric controls for counting, sorting, signaling, protecting, diverting, and detecting operations is described in Bulletin GEA-6822. Included in the line are self-contained relays, transistorized relays, explosion-proof relays, smoke-density indicators, electronic timers, cut-off register controls, and side-register controls. A relay selection guide is also included, and suggestions are given on how to select the proper relay.

Circle 477 on Page 19

Vacuum Pumps

Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.—16 page booklet—Line of Roots high-vacuum pumps is described in Bulletin 8-20. Data are given on six pumps which can operate at a wide variety of capacities to fit almost any application in the 50 mm to 10^{-6} mm Hg pressure range. Performance charts show operating characteristics and speed curves.

Circle 478 on Page 19

Furnace Brazing Techniques

Electric Furnace Co., Salem, Ohio—16 *page booklet*—The practical and economical aspects of furnace brazing of ferrous and nonferrous products are described in Bulletin 592. The correct and incorrect procedures for brazing and handling different types of assemblies are discussed. Other points covered include: Brazing temperatures, method of heating furnaces, and furnace atmospheres.

Circle 479 on Page 19

Magnetic Tape Recorder

Ampex Data Products Co., 934 Charter St., Redwood City, Calif.—20 page booklet—Model FR-100B, an instrumentation magnetic tape recorder, is the subject of booklet. Features such as six tape speeds and plug-in interchangeable heads are described. Performance figures for direct, fm, pulse duration modulation, and digital recordings are given. Notes are also included on accessories like a rack dolly, erase head, remote control panel, and servo speed control.

Circle 480 on Page 19

Molded Case Circuit Breakers

I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.—40 page catalog—Molded case circuit breakers are described in Bulletin 5001-1A, ranging from the smallest unit for lighting circuit protection to units with 100,000 amp interrupting capacities. Suggestions are given for the selection of a circuit breaker for

a given application and a selection chart indicates the ratings, overcurrent devices, attachments, and modifications available.

Circle 481 on Page 19

Drilling & Tapping Units

Hypneumat Inc., 647 W. Virginia St., Milwaukee 4, Wis.—24 page catalog—Air and hydraulic powered automatic drilling and tapping units are covered in Bulletin 5810. Construction features are noted and sketches show how the basic unit operates. Charts list the theoretical drill thrusts and schematic drawings show wiring circuits and applications for drilling, reaming, centering, boring, facing, and deburring operations.

Circle 482 on Page 19

Hose and Fittings

Aeroquip Corp., Jackson, Mich.—38 page catalog—Data are given in Catalog 204 on hose and fittings, adapters, self-sealing couplings, and cap-plugs and sleeves. Other items such as support clamps and protective sleeves are also covered. A hose selector chart is given listing the various applications and fluids for which specific hose types are recommended. Instructions for assembling hose lines are included, with sketches showing the procedures.

Circle 483 on Page 19

Explosion-Proof Controls

Partlow Corp., 531 Campion Rd., New Hartford, N. Y.—4 page pamphlet—Data are contained in Bulletin 1122 on explosion-proof controls for temperature ranges up to 1100 F. Photos show recording, indicating, and nonindicating models. Design features are noted, and it is explained how the electric controls are made explosion-proof.

Circle 484 on Page 19

Air Directional Valves

Industrial Products Div., Westinghouse Air Brake Co., Wilmerding, Pa.—16 page booklet—Data are listed in Bulletin A4-75.01 on 1172 different air directional valves. This includes 2-way, 3-way, and 4-way valves which can be operated by basic operators such as: Lever, button, cam, air pilot cylinder, solenoid, pedal, treadle, and low pressure pilot cylinder. Sketches show various applications and charts show outlet pressure.

Circle 485 on Page 19

Multipurpose Dumpers

Essex Conveyors Inc., 101 Colden St., Newark 3, N. J.—8 page bulletin—Catalog 59 shows actual working installations of multipurpose dumpers which can lift standard and special containers and dump all free-flowing bulk material into any type of receptacle. Mechanical features and safety factors are noted.

Circle 486 on Page 19

Magnetic Clutches

PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.—18 page booklet—A report is given on magnetic clutches and their applications in automatic control systems. Performance charts

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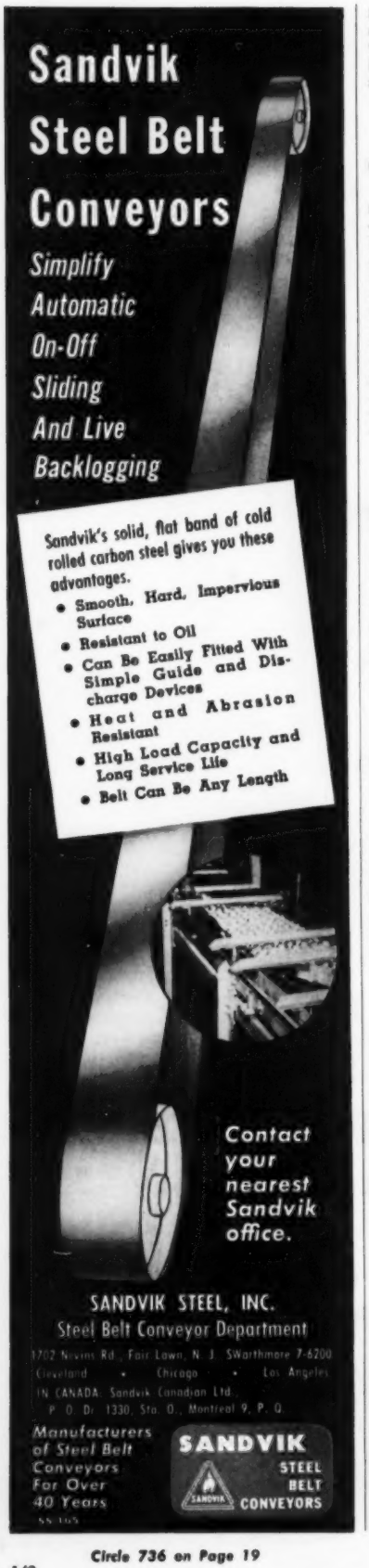
Circle 735 on Page 19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Circle 736 on Page 19

show temperature versus torque and voltage versus torque. Sketches show the action of the clutch when the magnetic coil is de-energized. Testing and technical specifications are also covered.

Circle 487 on Page 19

Computer Control System

Controls Div., Hagan Chemicals & Controls Inc., Hagan Bldg., Pittsburgh 30, Pa.—6 page pamphlet—Subject of Bulletin MSP-163 is PowrMag, a solid state analog computer control system. Components in the system are described, including solid state controllers, with operational magnetic amplifiers, interchangeable components, remote control station and central patchboard networks that interconnect the system. Diagrams show how the interchangeable circuits can be used for control functions such as addition, subtraction, multiplication, ratioing, differentiating, and integrating.

Circle 488 on Page 19

Mineral Insulated Thermocouple

Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.—20 page booklet—Line of mineral insulated thermocouples with over 24,000 assembly combinations is described in Catalog 300. Ordering instructions are noted, and sketches show the steps taken in manufacturing and testing the units. Data are also given on the line of hot junctions and terminations.

Circle 489 on Page 19

Word Indicator Lights

Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif.—16 page booklet—Rotating word indicator lights described in Catalog 159C have a visible legend area of 15/32 by 1¼ inch, will accommodate up to three rows of 0.125-inch high characters, fourteen per row. Schematic diagrams show dc circuits positive input and dc circuits negative input. Also included are outline and mounting dimensions.

Circle 490 on Page 19

Coolant Cleaning Equipment

Barnes Drill Co., 836 Chestnut St., Rockford, Ill.—8 page bulletin—Fabric filters and combination magnetic and fabric filters described in Bulletin 100 can automatically remove sludge from coolant in grinders, gear shavers, automatic screw machines, broaching machines, and thread rolling machines. A photo of the interior of the filter is given, as are installation illustrations. Schematic drawings show the cleaning action of the filters.

Circle 491 on Page 19

Bases for Valves

Hannifin Co., Dept. 142, 501 S. Wolf Rd., Des Plaines, Ill.—4 page pamphlet—Bulletin 235 covers alternate bases and the integral speed control section for company Series CC 4-way air valves. Operation of the integral speed control section is explained, and dimensions and specifications are given. Variations of the directional air control valves are discussed, as is the piping versatility of the valves.

Circle 492 on Page 19

Air Gages

Air Gage Div., Dearborn Gage Co., 32330 Ford Rd., Garden City, Mich.—16 page booklet—Line of precision air gaging instruments and elements is described. This includes column-type and dial-type air gaging instruments. The air gage elements include normal and reverse contact type cartridges in both short and long range models, open orifice and contact type spindles, true and average type air gage rings, and both open orifice and contact type air gage snaps.

Circle 493 on Page 19

Rack & Pinion Roll Feeds

Automation Div., F. J. Littell Machine Co., 4101 N. Ravenswood Ave., Chicago 13, Ill.—16 page booklet—Rack and pinion roll feeds for OBI presses are described in Bulletin A-11. Basic principles of the roll feed design are explained, as are the various types of lifters and rolls. A specification chart for selecting the proper roll feed is included and illustrations show the various operating positions of the feeds on punch presses.

Circle 494 on Page 19

Manual Record Systems

Remington Rand Div., Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.—12 page booklet—Bulletin KD 854 entitled "Visible Control of Machine Systems" explains how visible recordkeeping systems and housing equipment can facilitate sound management decisions. It discusses advantages in inventory, sales control, and accounts receivable. Other points covered include visible cross-reference equipment, various types of cross-reference holding devices, and marginal punched continuous forms for uniform machine indexing.

Circle 495 on Page 19

Air Motors

Gardner-Denver Co., Quincy, Ill.—8 page bulletin—Data are given in Bulletin AM-1 on 5-cylinder radial air motors which are suitable for driving winches, conveyors, diamond drills, and pumps. Specifications and dimensions are listed, and a cutaway photo shows the construction of the motor.

Circle 496 on Page 19

Furnace and Oven Controls

Minneapolis-Honeywell Regulator Co., Wayne & Windrim Avenues, Philadelphia 44, Pa.—40 page catalog—Furnace and oven controls described in Bulletin B43-1C covers Electronik potentiometers, millivoltmeters, thermocouples, Radiamatic detectors, thermometers, flame safeguard systems, industrial controls, and final control elements. Data are given on the different styles of these units, supplemented by sketches and diagrams.

Circle 497 on Page 19

Electronic Solution Controller

Electro Mechanisms Corp., 7301 Ridgeway Ave., Skokie, Ill.—4 page pamphlet—Electronic solution controller is described which can automatically control the con-

centration of caustic, acidic, or aqueous solutions in either continuous or batch-type metal washing equipment, plating processes, chemical process systems, or textile bath equipment. Notes are also given on the components such as the sensing electrode, magnetic amplifier, pump assembly, wash tank, and holding tank.

Circle 498 on Page 19

Pneumatic Processing Equipment

Fuller Co., Catasauqua, Pa.—12 *page booklet*—Bulletin G-3C covers equipment for the process industries which can be used for pneumatic conveying of dry granular and pulverized materials; plant air supply and vacuum service; cement processing; and handling of combustion products. Some of the equipment includes compressors and vacuum pumps, coolers and preheaters, and gas and vacuum pumps. Installation photos are included, and schematic diagrams show operating principles of the different systems.

Circle 499 on Page 19

Air Hydraulic Drill Unit

Hartford Special Machinery Co., 287 Homestead Ave., Hartford 12, Conn.—6 *page pamphlet*—An air hydraulic drill unit—Model 17-400—is the subject of Bulletin GC-400. The unit is designed as a building block component for assembly into automatic machines. Dimensional drawings and electrical and hydraulic diagrams are included.

Circle 500 on Page 19

Hermetically Sealed Enclosures

Automatic Electric Co., Northlake, Ill.—32 *page catalog*—Hermetically sealed and protective enclosures for relays, switches, and control packages are described in Catalog 4083-A. Photographs and line drawings show the various housing sizes and shapes available with quick-connectors. Wiring diagrams are also included.

Circle 501 on Page 19

Control Valves

Ross Operating Valve Co., 120 E. Golden Gate, Detroit 3, Mich.—20 *page booklet*—Data such as envelope dimensions, model numbers, pipe sizes, JIC symbols, and specifications are given for solenoid operated, air operated, hand operated, foot operated, and cam operated valves. Auxiliary, special, and custom valves are also covered. Cutaway drawings of the valves are shown and the various types of pneumatic circuits are explained.

Circle 502 on Page 19

Marking Equipment

Industrial Marking Equipment Co. Inc., 655 Berriman St., Brooklyn, N. Y.—8 *page bulletin*—Line of marking, dating, coding, and imprinting machines is described which can imprint messages on almost any kind of carton, package, box, can, bag, wrapper, or container. Data are also given on a transleaf coding attachment designed for flexible wraps such as polyethylene, pliofilm, cellophane, waxed paper, and foil.

Circle 503 on Page 19

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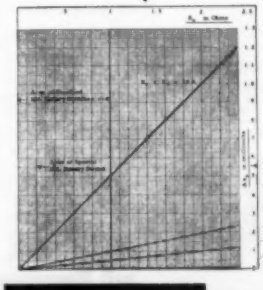

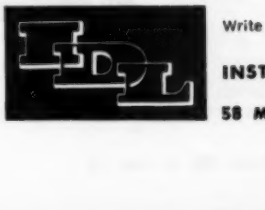

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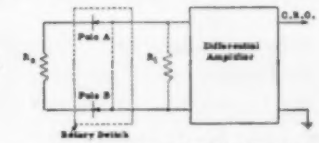

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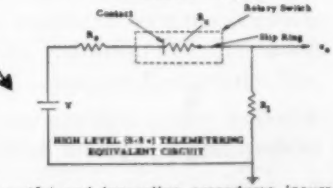

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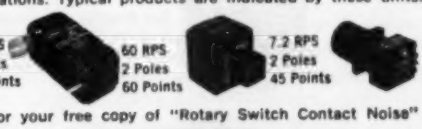

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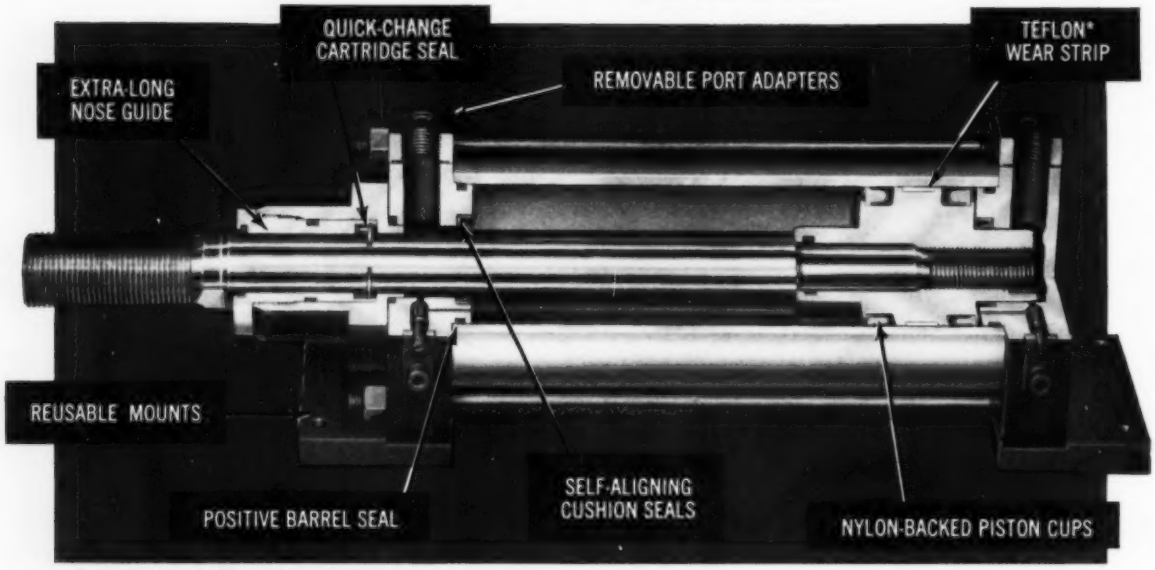

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AUTOMATION abstracts

FILTERS FOR ELECTROHYDRAULIC SERVO SYSTEMS

By JOHN A. FARRIS
Manager, Engineering Liaison
Aircraft Porous Media, Inc.
Glen Cove, N. Y.

WITH the advent of electrohydraulic servo control systems, filtration requirements have had to be re-evaluated. The degree of filtration which was generally satisfactory for older types of hydraulic systems has proved inadequate for systems containing electrohydraulic servo valves.

From the standpoint of sensitivity to contaminant, the following areas of an electrohydraulic servo valve are critical: 1. Nozzle. 2. Flapper. 3. Spool and sleeve. 4. Magnetic gap in wet-motor servos. Due to fluid contamination these critical areas may be sources of failures that can be grouped into the following categories: 1. Sudden hard-over signal of the servo actuator. 2. Locked position of servo actuator. 3. Oscillations of the servo actuator. 4. Gradual drift in the position of the servo actuator. All such failures are not necessarily caused by contaminant, but can also be caused by hydraulic, mechanical, or electrical malfunctions.

Filter Requirements

Degree of Filtration: An ideal filter should remove all insoluble contaminants from the hydraulic fluid. Because it is not practicable to remove all of the insoluble contaminant from a hydraulic fluid, particle number, size, and type limits must be defined. To assure that the limits set are maintained, test methods have been devised to measure the degree of filtration.

Nominal Rating: Nominal ratings are generally defined by Military Specifications MIL-F-5504A and B. A 10-micron filter is defined by MIL-F-5504A as being capable of removing 98 per cent, by weight, of all particles exceeding 10 microns of the selected contaminant, AC fine test dust, at a certain high concentration. MIL-F-5504B defines a 10-micron filter as being capable of removing 95 per cent by weight of 10-to-20 micron glass beads at a certain high concentration.

Absolute Rating: Absolute filtration ratings are defined by proposed specifications MIL-F-8815 and MIL-F-25682 (USAF). The rating is determined by measuring the diameter of the largest glass bead to pass through the filter. It is equivalent to the point at which a filter is 100 per cent efficient. The absolute filter rating is not affected by changes in contaminant type or concentration, thus it is a very useful parameter.

A very simple test, called the bubble point test, is used as an inspection test to measure the maximum particle passed by a filter and thus determine the absolute rating of the filter, *Fig.* 1. The bubble point test can also be used to measure the size of the second, third, etc., largest holes and that of the general hole size of the filter medium; i.e., the pressure at which bubbles appear over the entire surface of the filter medium.

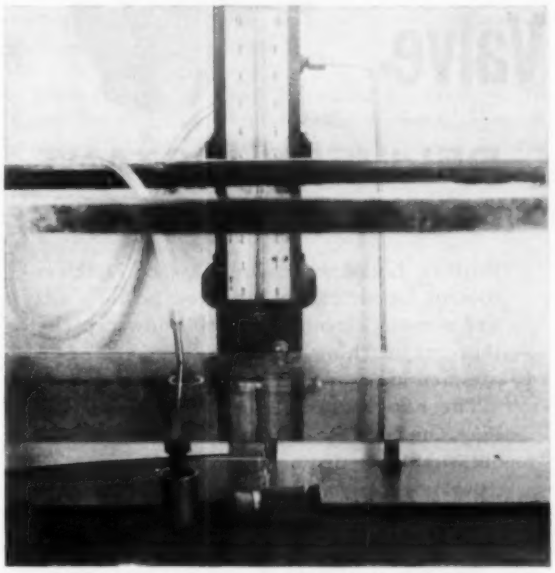

Fig. 1—Filter to be checked for absolute rating can be given simple bubble test as shown. Element is immersed in a specified fluid and air pressure applied to inside of unit as it is rotated slowly. Pressure at which first continuous stream of bubbles is produced is a measure of the size of largest hole.

Magnetic Efficiency: Wet-motor servo valves also require the use of magnetic filters. To protect a servo valve adequately a magnetic filter should be able to remove and retain magnetic particles in the range of one micron and larger.

The weight efficiency of a magnetic filter is determined by measuring the weight of a magnetic contaminant which passes through. A typical value of a well-designed magnetic filter is 94 per cent, measured using a Carbonyl Iron E concentration of 0.20 grams per gpm.

Dirt Capacity: A filter must exhibit adequate on-stream life without servicing. The service interval is

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dependent upon the size and type of contaminant, the flow rate, and the condition of the hydraulic oil. Comparative service intervals can be obtained by measuring the amount of AC fine test dust required to raise the differential pressure to 90 psi or to some other arbitrary value.

A typical dirt capacity for a 12 gpm absolute 15-micron filter element, measured with a system clean-up filter, is 3.5 grams to 90 psi differential pressure. The same size element rated at absolute 25 microns would have a typical dirt capacity of 5 grams. Generally the filter area and dirt capacity are proportional to the flow rate, thus values for other flow rates can be readily calculated. Dirt capacities are often expressed in grams per gpm rated flow.

Migration: Another requirement of a servo valve filter element is that it should not release contaminant downstream of the element. Released contaminant is of four basic types. The first is called media migration and occurs when part of the filter medium breaks away and adds itself to the system contaminant. The second type is called "built-in dirt migration." All types of filter elements made from all media suffer from the disadvantage of having dirt released in use which was trapped in the filter element during manufacture. The third type is called abrasion migration. The abrasion particles are generated in a vibration environment between a poorly designed filter element and filter housing. The fourth type is called contaminant migration. It is applicable to media that change porosity under varying conditions of flow and pressure drop. In such a system, and this includes almost all servo systems, contaminant stopped on the upstream side of the filter media slowly works its way through the media and is ultimately released on the downstream side.

Structural Strength: A servo valve filter must be constructed to withstand all structural and operational loads to which it will be subjected over its entire temperature range.

Compatibility with Hydraulic Fluid: A servo valve filter must not affect or be affected by the hydraulic fluid at either the high or low operating extremes of temperature. Some types of filter media slowly dissolve or disintegrate in certain hydraulic fluids. Other types of media have the ability to remove corrosion inhibitors, viscosity improvers, or other additives from hydraulic fluids.

Filter Media Types

Filter media can be broken into two general categories for purposes of discussion; depth and surface. Paper, felt, cellulose, glass fiber, wood pulp, diatomaceous earth, and sintered powders are generally used as depth media; they depend upon a relatively long tortuous path to accomplish the removal of contaminant. Wire mesh and membrane are generally used as surface media; dirt is removed by a plane surface containing fairly uniform orifices. Thus, most if not all, of the contaminant is on the surface of the medium. All media act, to varying degrees, as both surface and depth media. For instance, every depth medium retains some particles on its surface, and there is some penetration of particles into almost all surface media. Also, all surface media ultimately build up a surface

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contaminate cake which, in turn, acts as a depth medium.

For the greatest dirt capacity and removal of contaminant from hydraulic oil, combinations of surface and depth media are usually optimum. The depth medium provides dirt capacity and removal of fine particles; the surface medium used downstream of the depth medium provides for absolute control of maximum particle and retention of media and contaminant migration from the depth medium.

Filter Housing

The filter housing must be designed to withstand the structural loads of installation, use, and environment of the system. Maximum filtration reliability is obtained when there is no relief valve to bypass a filter element; and style-B nonbypass housings are recommended for servo system applications. An automatic shut-off is recommended for filter housings used in servo systems. This prevents air inclusion, and eliminates drainage of part or all of the system when a filter element is changed. The filter housing is often a convenient place from which to bleed air. A bleed port can be provided if required. A differential pressure indicator can save countless maintenance hours and prevent unnecessary opening of the hydraulic system. For systems that must be capable of operation below 32 F, a thermal cutout can be provided to prevent false indications resulting from increased fluid viscosity at low temperature.

Media Recommendations

For industrial applications the ideal medium is a glass fiber and membrane combination rated at 3 microns absolute. This type of filter is available in high-dirt-capacity high-pressure configurations, which allows them to be used immediately upstream from the servo valves.

For optimum operation, a servo system should be assembled with precleaned components that are absolute 3-micron pressure-flushed immediately before installation. The assembly area should be dust controlled. Dummy servo valves should be installed initially, and the system should be absolute 3-micron pressure flushed (with turbulent flow where possible) until the contaminant level, as measured per ARP 598, levels off. The servo valves should be installed and the flushing continued until the contaminant level again levels off. Flushing should be repeated any time the system is opened. It is essential that the cleanliness level and filter requirements be included as part of the original specifications for electrohydraulic servo control systems. With such specifications, proper coordination of cleanliness level with performance requirements will be achieved.

From a paper entitled, "Hydraulic Filtration As Applied To Electrohydraulic Servo Control Systems" presented at the Fifteenth Annual Meeting of the National Conference on Industrial Hydraulics, Chicago, Oct., 1959.

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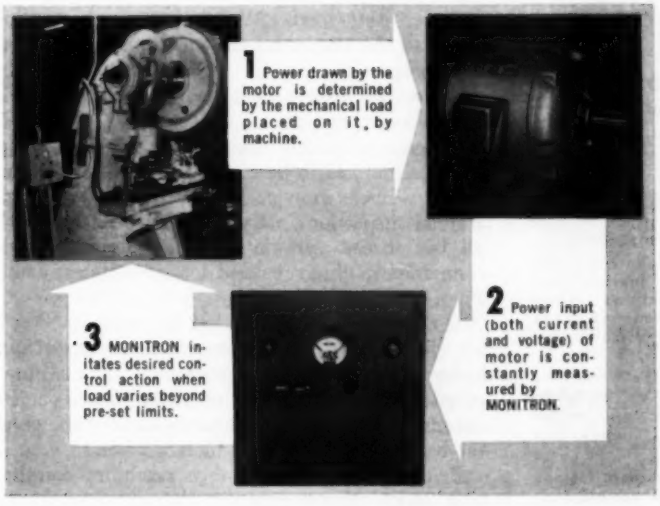
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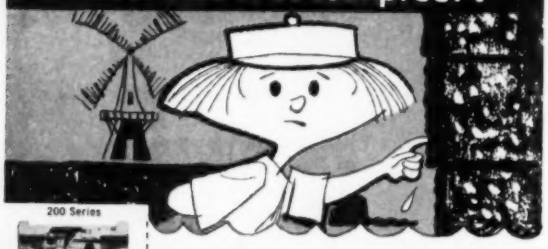

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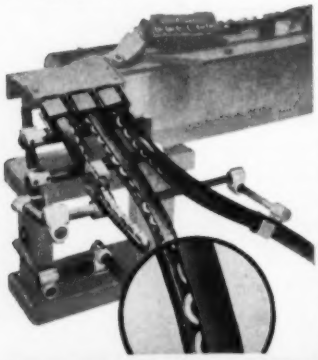

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QUALITY FOR AUTOMATIC ASSEMBLY

By E. SUMMERSCALES
Chief Quality Engineer
Joseph Lucas (Electrical) Ltd.

AUTOMATIC assembly represents a logical extension to the more-and-more automatic production of components. The latter has been developing ever since production engineering started and, as is well known, has now reached an advanced stage. When large capital expenditure has been made to set up an automatic assembly line, the prime concern is to make the line pay for itself and to do so as quickly as possible. This implies that its working efficiency must be high. Stoppages will inevitably occur due to breakdown; but, if the production engineer has designed his machine effectively, a much more likely cause of downtime will be the geometrical variation in components.

Under more conventional assembly methods, the quality consideration of components was one of functional quality. Automatic assembly demands that, in addition to functional quality, there must be a quality in terms of uniformity.

Consider the case of four slotted head screws driven into a fuse-base. When this product was made by hand assembly, the only quality characteristics were the presence of an adequate driving slot and correct thread form and length. The assembly operator could be relied on to deal with these simple requirements and reject bad screws.

The machine assembling automatically makes no discrimination. Suppose, for instance, that five screws are being driven simultaneously every seven seconds and that the screws are 99.5 per cent good. How often will the machine stop because of faulty screws? About every 40th assembly, which is about every five minutes. If the screws are only 99 per cent good, this stoppage rate is doubled.

The implications are not yet fully worked out because we now have to look at what we mean by 99.5 per cent good. We cannot simply confine ourselves to the characteristics mentioned before for other vital properties creep in. These are: 1. Diameter and thickness of head variations. 2. Milling burr at the end of the screw slot.

Experience quickly showed that a simple component like a screw has to be controlled in all dimensional respects whereas previously, a practical, working, commercial inspection interpretation would have tolerated all but thread variations. With automatic feeding of components, slide rails and locations demand uniformity of component, if jams are to be avoided.

How can such a situation be tackled? Possibilities are: 1. Design the equipment to take the sort of minor faults liable to occur in production. 2. Institute a detailed manual inspection of components. 3. Buy an automatic inspection machine to sort out the good from the bad. 4. Refine the production process.

Before automatic assembly machines can be built with more than a sporting chance of working, component accuracy and variability must be studied in great detail. It is conceivable that where there is no previous information to guide the machine designer, components will have to be produced before the dimensions of the assembly machine can be fixed. That is rather ex-

treme action, but it is perfect in conception. Statistical techniques can be used to great advantage here, and they will no longer have to be considered solely as in the quality engineer's province.

To the uninitiated, detailed manual inspection seems a simple solution. There are snags, however. In the first place, there is no such thing as 100 per cent human inspection. Some people cling to the belief that there is; but any practising inspection supervisor will know that there is not. Human minds wander from the task in hand, particularly if it is a monotonous one, and judgments vary. And are the direct labor savings of automatic assembly going to be dissipated because of increased inspection costs? That would be false economy indeed. On the grounds stated, production engineers are advised to forget human inspection-sorting activities in the context of automatic assembly.

On what grounds can the expense of automatic inspection of components be justified? If the cost of loss of output through downtime is considered, then the value of the machine can easily be assessed. Without any feedback to the production process, this type of automatic inspection is simply sorting and does nothing to improve the quality of production. Machine control of the component production is the answer, but may be ruled out on economic grounds.

There is the possibility that fresh capital will have to be spent to refine the production process if the present process is really doing all that can be expected of it. An example in the case of the screws is that a headed screw will be subject to much less variation than a turned screw in its head form and will be safer as an automatic assembly component. Uniformity of components has been my main theme; but there is another aspect to be considered. The correct number of components has to be present in the assembly. The testing of the finished product must also be incorporated into the process.

Obviously, the functional requirements of the product are paramount; but more and more attention will have to be directed towards design which permits easy automatic assembly. It is suggested that centers of gravity of components will have to be considered, whereas formerly they were of no consequence. Under gravity feed, the way things fall is important. Good location faces will have to be provided as datum surfaces and shapes, in general, will become more important. Conventional ideas will have to be abandoned. For instance, the slotted screw head seems out of context in automatic assembly. The slot has to be reasonably central for one thing. It seems out of place that the hand screwdriver should still dominate our thinking. The recessed head screw, or even one with a convex form, seems more appropriate, enabling the drive to be taken up over a wider range of engagement.

If large expenditure is to be incurred in setting up automatic assembly, there has to be stability of design. Modifications cannot be contemplated lightly. Design development will tend to move in larger steps than formerly. Ideas will be stored for group changes.

Based on a paper entitled "Quality and Automatic Assembly," presented at the Conference on Quality in Industry organized by Institution of Production Engineers, Institution of Engineering Inspection, and British Productivity Council at Buxton, England, June 1959.

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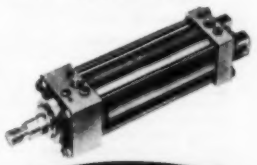

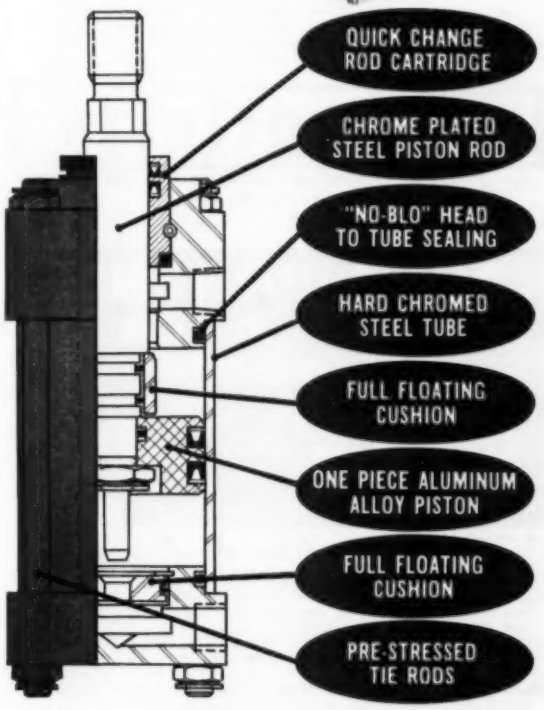
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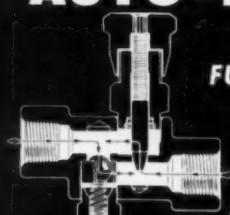

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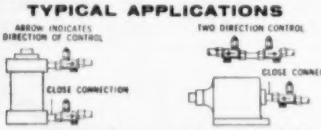

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APPLYING SMALL VIBRATORY FEEDERS

By ARLO F. ISRAELSON
Chief Engineer
Eriez Mfg. Co.
Erie, Pa.

THERE IS actually no sharp dividing line between small and large vibratory feeders. However, feeders whose rated output is 10 tons per hour or less are usually classified as small feeders and are generally used in applications where space limitations prevail and where more precise control of the material flow is necessary. It should be emphasized that small vibratory feeders cannot be so precisely controlled that they can take the place of automatic weighing, packaging, or parts counting machines.

The versatility of vibratory feeders is accented by the fact that, in addition to the most commonly used troughed-pan type trays, they may be fitted with trays of other configurations. Other shapes commonly used are tubular, half round, and V-shape. The many possible dimensional variations of these shapes make them adaptable to countless applications.

Trays may have built-in heating elements for heating, drying, or maintaining heat in products being conveyed, or may even be water-jacketed for feeding materials such as glass batch to a furnace. They may be made of steel, aluminum, or stainless steel with special finishes or coatings such as Teflon, glass, or epoxy resin when needed.

The addition of one or more screens to trays is common practice for separation, grading, or de-dusting of materials. Still another variation is to use corrugated or divided tray bottoms to separate products into rows, placing them in alignment for packaging or some other process.

To make an intelligent appraisal and recommendation for any application, the following information is required: 1. Description of material to be fed—weight per cubic foot, particle size, adhesive or cohesive characteristics, moisture content. 2. Volume of material to be fed. 3. Manner in which material is to be introduced to tray. 4. Type of tray desired—flat pan (open or covered), V or half-round, tubular. If for screening, complete specifications including mesh size. 5. Description of any connections or attachments. 6. Voltage and cycles of power supply (units will not operate on direct current). 7. Any other pertinent information—extreme temperatures or unusual atmospheres, method of discharge (alignment, spreading, dusting, and so on), any unusual electrical control.

Accurate "Feeder Capacity Charts" are nonexistent. However, rule-of-thumb guideposts have been established for a wide range of materials. Laboratory testing of samples of special materials is recommended.

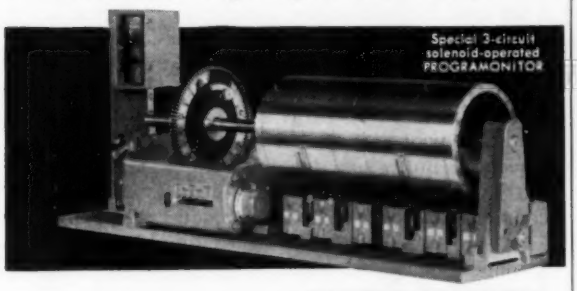
Another feeding aspect that should be recognized is that the output from a feeder can be no more consistent than the input to the feeder. If materials flow in surges from a hopper into a feeder, they will probably be discharged in the same pattern—especially with tangled materials or materials with a steep angle of repose. Free-flowing products have a tendency to level out.

Another factor which can influence feed rates is the

Complex switch patterns . . . simply set . . . with

PROGRAMONITOR

automatic recycling circuit control



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- Adjustable overall cycle settings . . . ranges up to 4,000 counts or time increments.
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- Ends need for change gears, complex cam systems, costly control circuits, awkward mechanical stops.
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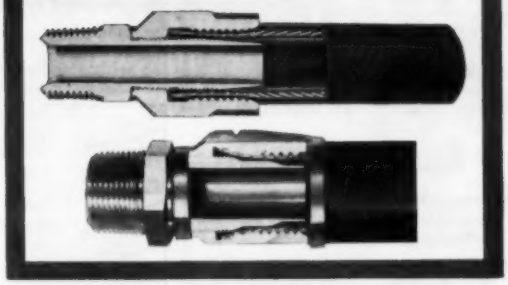
Circle 745 on Page 19

Reusable Couplings

for Cotton Cover–1 and 2 Wire Rubber Cover Hose



Cutaway views show how EASTMAN Two-Piece Couplings are engineered to permit full flow through maximum orifice. Hose is molded into precision-machined recesses for firmer grip and longer life.

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WRITE for Technical Bulletin 100 for all sizes and styles.

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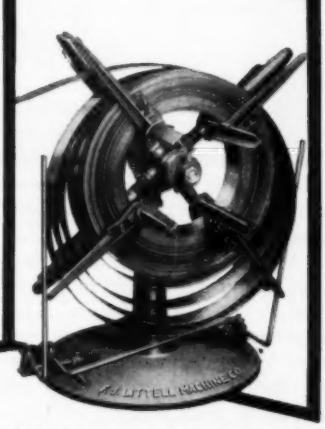

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with 300% greater holding power!

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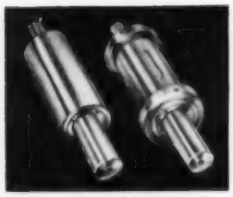

(Left) plain type. (Right) with longitudinal positioning nuts. Both are shown with BLANK SPINDLE END for machining by user.

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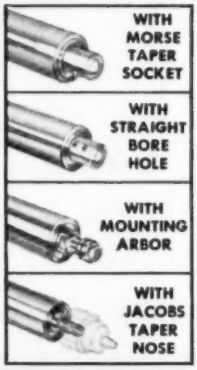
CARTRIDGE-TYPE
SPINDLE ASSEMBLIES

. . . available from stock in **28** *standard types and sizes*

AVAILABLE in plain cylindrical type or with longitudinal positioning nuts. Five types of spindle noses are offered. Range of cartridge diameters from 1.250" to 2.750".



Design Advantages

- Steel spindles are precision machined and ground, with close tolerances maintained throughout.
- Matched, double-row ball bearings at tool end of spindle . . . single-row ball bearings at the driven end.
- Positioning nuts are graduated in increments of spindle adjustment of 0.001".
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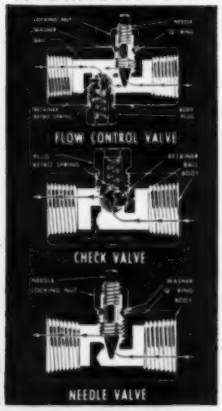
2,000 (brass or aluminum) and 5,000 (steel) p.s.i.

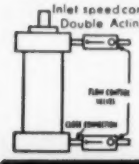
with Pneu-Trol® VALVES IN AIR OR HYDRAULIC USE



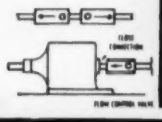
Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — 1/8" to 3/4". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

Write for Illustrated Circular and Price List.

Inlet speed control for Double Acting Cylinder.



Single Acting Cylinder Speed Control.



AUTO PONENTS INC 2939 GRANT STREET
BELLWOOD (Chicago Suburb) ILLINOIS

angle of the feeder tray. If the feeder slopes downward, the output will generally increase about 5 per cent for each degree of slope. If it is inclined upward, the output will usually be decreased by approximately 5 per cent for each degree (maximum 15 degrees).

Column loads—the weight of products in bins or hoppers that actually bears upon the tray—are serious to vibratory feeders. With well-designed bins or hoppers the material discharge will be baffled or deflected in such a way that column loading will be of no consequence. But where the full column load bears directly upon the feeder tray, its weight should be calculated and added to the normal product load being fed.

It is to be expected that when tubular, half-round, V-shaped, or special tray configurations are used, reductions in maximum output will result.

Some of the most difficult performances to predict with vibratory feeders are those encountered in problems of screening. Because customer objectives and product behaviors are so varied, it is recommended that screening problems be referred to the feeder manufacturer for recommendations.

The most frequent variation from standard products occurs either in tray size or configuration. Any major departure from established standard dimensions or weights could result in poor feeder performance unless certain basic rules of tray design are observed. A common rule of thumb is that usually a tray may be a maximum of 50 per cent wider or 50 per cent longer than the largest standard size—but not both. The heaviest standard tray or tray load may also be exceeded by 50 per cent, but it is to be expected that in the case of such extremes the total volume output would be something less than maximum.

In the design of vibratory feeders, tray size, weight, and weight distribution are important. For best performance, the center of gravity of the tray, or moving mass, should be as nearly as possible in line with the line of drive and the center of gravity of the reaction mass, or feeder body. It has also been learned that the weight of the reaction mass must be from 2 to 4 times the weight of the moving mass. If a tray is off balance, it can result in poor performance because of improper location of the center of gravity.

Either flexible or rigid connections or additions to feeders or trays, which could restrict or otherwise influence the carefully engineered mass-spring relationship, should not be made without expert engineering study and advice.

A complete line of controls has been developed for controlling the voltage supply to all models of vibratory feeders and unit vibrators. The controls include either a potentiometer or a variable autotransformer, a switch, and for some models, capacitors for power-factor correction. By means of these controls, volumes can be regulated from a mere trickle to a rushing torrent.

One must remember that feeder output is almost directly proportional to the voltage supply and that a voltage fluctuation of plus or minus 10 per cent is not uncommon. Installation of a voltage regulator can reduce this variable to plus or minus 1 per cent.

From a paper entitled, "Development and the Uses of a New Line of Vibratory Feeders and Unit Vibrators" presented at the Semiannual Meeting of the American Society of Mechanical Engineers, June, 1959.

PRAB PRECISION ENGINEERED Specialized CONVEYING EQUIPMENT

MAGNAVATOR

Automatically- ELEVATE YOUR SMALL PARTS *Magnetically* WITH THE

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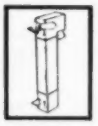
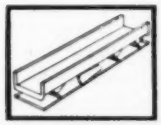
PARTS FEEDING CONVEYOR

MAGNAVATOR eliminates manual labor usually required for filling hoppers and transferring between machines . . . conserves valuable floor space . . . automatically handles up to 8000 lbs. per hour . . . serves two or more machines. The self-feeding **MAGNAVATOR** efficiently handles small parts up to 8 lbs. each, such as castings, bolts, nuts, forgings, rivets, stampings, etc. The automatic **MAGNAVATOR** can greatly reduce your materials handling costs.



BUCKET ELEVATOR



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Advantages: Self-feeding · maintains material level automatically · pleasing appearance, portable · vertical handling saves floor space · hot parts can be handled · no jamming · each unit engineered to YOUR specific requirements.

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Circle 751 on Page 19

count, inspect, control

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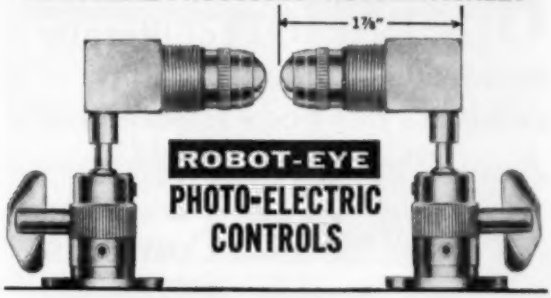

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Small, for "tight-spot" installation, yet **rugged** for long service. **Accurate,** for precise automatic control in virtually any industry.

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Plug-in terminals available for quick connection to any of a wide range of Amplifiers. This design enables you to select the most **economical** amplifier for your job requirements.

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Standard Set P-5 is **$17.** Set P-5S is **$21.** Amplifiers start at **$39.50.** For complete data, write for Brochure LP-2.

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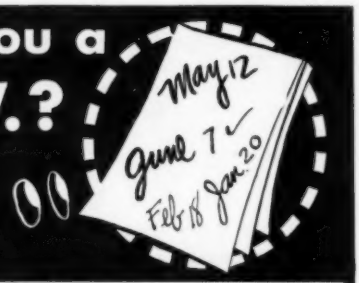
are you a *D.W.?



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For those manufacturers who are faced with manufacturing problems, we offer a free bulletin illustrating many stampings we have produced, as well as a sample and cost summary of an actual part. We also offer free quotations from your blueprints at any time.

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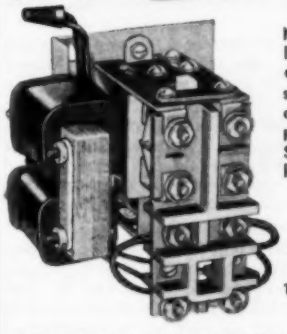
give you all these advantages!



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Write for 32-page Catalog which gives complete specifications

Two pole control shown at left

YOU CAN USE OUR CONTROLS FOR:

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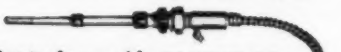
Circle 754 on Page 19

Improved Operation of literally hundreds of mechanical products has been effected with Acco Tru-Lay *flexible* PUSH-PULL Controls

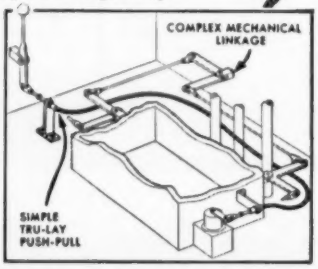


Tru-Lay Push-Pull Controls provide POSITIVE REMOTE-ACTION over long or short distances . . . with fixed or movable anchorages . . . for light loads or loads up to 1,000 lbs., and these units are frequently and successfully used in conjunction with Electric, Hydraulic and Air Controls.

Flexibility makes it possible to snake around obstructions . . . simplifies installation . . . reduces the number of working parts . . .

Simplicity vs Complexity

Compare the TRU-LAY PUSH-PULL cable in illustration with the mechanical linkage. PUSH-PULLS are simple, have but one moving part, are noiseless and give lifetime service accuracy. Linkages are complex, made of many parts; they wear at many points. Their use brings increased backlash, lost accuracy and vibration rattles.



Positive Remote-Action and Flexibility, together with Precision and Long Life, explain why TRU-LAY PUSH-PULLS serve designers and users equally well in improving machine operations, whether the application is on such severe service jobs as Bulldozers, Power Shovels and Steel Mill Machinery, or on such light duty work as Photographic Equipment, X-Ray or Business Machines.

Immunity to Vibration makes these TRU-LAY PUSH-PULLS ideal as Remote Controls on shakers and other vibratory products.

Complete Protection Against Dirt and Moisture is a big factor in the use of this unit on machinery in Coal Mines, Cement and Steel Mills, Oil Fields and in many other industries.

Corrosion-Resistance of the unit, plated or with Stainless Steel construction as required by the use, has led to many applications in the Marine Field . . . salt water or fresh. Supplied with a rubber cover the unit operates effectively even when conduit is COMPLETELY IMMERSED.

Lubrication of the inner working member is for life.

Temperatures as low as —70°F will not hinder the proper operation of this unit, and it is thoroughly effective even in the extreme high temperatures encountered on Jet Engine, Furnace Door and Glass Furnace Damper control applications.

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Readers with problems concerning systems, equipment, or components for automated operations are invited to outline them to: The Editor, AUTOMATION, Penton Bldg., Cleveland 13, Ohio. Readers having solution suggestions are invited to submit them and should refer to case number and title of the problem involved. Dates shown with suggestions indicate issue in which the problem was presented.

CASE 2006-P

HANDLING PARTS BETWEEN DIES

. . . We are a supplier of stampings. In many cases our dies are set up in a cluster on a bolster plate, and we assign two, three, five, or possibly six men to operate a press and handle the parts between dies as a group operation. We would like to perform the transfer of parts from one die to another by mechanical or other means. Marketing requirements for our products dictate model changes at approximately yearly intervals. We cannot consider a heavy investment in some specific equipment unless it can be made adaptable to model changes . . .

Chief Engineer

CASE 2007-P

GRAIN HANDLING EQUIPMENT

. . . We would be pleased to receive any available information relative to automation of grain handling equipment in grain elevators. This request particularly applies to equipment other than automatic weighing devices and remote distributor valves. We are primarily interested in the possibility of applying automation to our belt conveyors and bucket elevating legs in the handling of bulk grain . . .

General Superintendent

CASE 2010-F

FILLING GRANULAR MATERIAL

. . . We are interested in a method, adaptable to automation, to settle and pack a dry, 36-40 grit, carbotronic grain. This material is a form of treated carborundum which is to be filled into a body approximately 18 inches long with a 2¼ inch inside diameter. The bodies are to be conveyed and processed in a vertical position throughout our production line. Any information on the handling of this or similar material will be appreciated . . .

Machine Designer

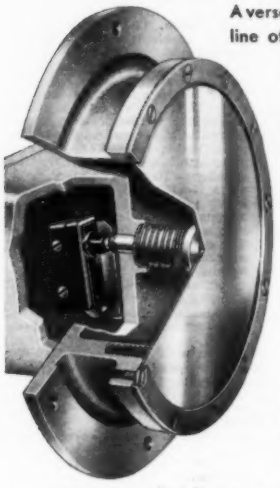
SUGGESTION FOR 1929-P (OCT. 1959)

LIGHT STRIP CUTOFF

. . . We have electronic sensing devices which might do this job. If the strip is controlled as to start, stop, and feed, a sensing device could be placed five feet (for example) from the blade. In view of the feed speed involved, two points might be used, the first serving to slow the rate of feed, the second to give precise time that cutting is required . . .

George W. Laub
Security Controls Inc.

NEW
AUTO-BIN-DICATOR*
AUTOMATIC BIN LEVEL INDICATOR



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NEW corrosion-resistant construction

NEW stainless steel diaphragm

NEW super-sensitive operation

Explosion-proof and general purpose models listed by Underwriters' Laboratories, Inc.

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Circle 757 on Page 19

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MINIATURE INDUSTRIAL QUALITY SOLENOIDS *with* MULTI-MILLION CYCLE PERFORMANCE!

The DECCO 01 and 02 series, miniature solenoids have the same quality and performance standards as the well known standard size DECCO solenoids.

From silicon steel laminations to new, thirty-second coil replacement feature they incorporate the best in quality and engineering.

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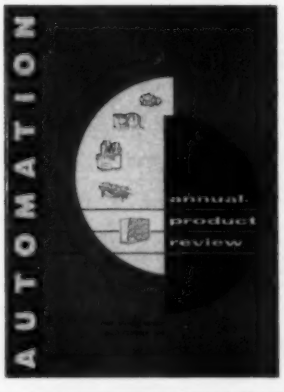
Circle 758 on Page 19

Looking for some new ideas?

You'll find them fast in this FREE 36-page booklet. Contains complete, concise reviews of automation equipment, products, components and services advertised in AUTOMATION during the 12 month period October 1958 through September 1959. Describes 400 separate items; indexed for fast, easy reference. Limited quantity on hand, so write for YOUR free copy NOW!



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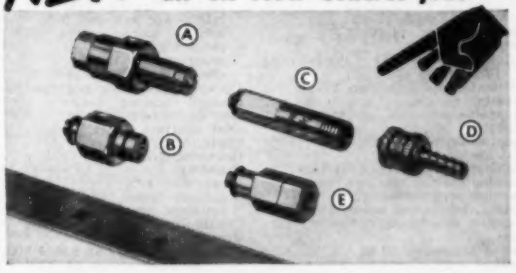
NEW MIDGETS for MAN-SIZED air-oil Flow Control jobs!



Ⓐ **MINIATURE FLOW CONTROL** — Operates on 1 lb. differential. Limited check one direction — full flow other. Recommended working range 0-250 psi. Air flow rate 3.6 CFM at 50 psi.

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By George F. Hawley, director of development & engineering, Automation Engineering Laboratory Inc.; 147 pages, 6 by 9¼ inches, published by Reinhold Publishing Corp., New York; available from AUTOMATION; *$4.95 postpaid.*

As applied to discrete products, the essence of the automation problem is devising machines that will work within the bounds imposed by economic considerations. This practical summation of the problem establishes the tone of this book. The author follows the various logical stages in the creation of equipment—proceeding from invention through the run-in period. His purpose in writing this book is to sharpen management's awareness of the kind and depth of problems that confront the automation team in successfully completing an automation project.

FLOW MEASUREMENT AND CONTROL

By W. F. Coxon; 312 pages, 5½ by 8¾ inches, published by the Macmillan Co., New York; available from AUTOMATION; *$11.00 postpaid.*

Object of this British book is to present representative information for the practical measurement and control of flow as opposed to a theoretical treatment of the subject. Primarily it should appeal to the younger engineer as an introduction to various industrial applications; and to technicians desiring to extend their knowledge of fundamental data.

ELEMENTARY DECISION THEORY

By Herman Chernoff, professor of statistics, and Lincoln E. Moses, associate professor of statistics, Stanford University; 364 pages, 6 by 9¼ inches, published by John Wiley & Sons Inc., New York; available from AUTOMATION; *$7.50 postpaid.*

Primarily a textbook, this offering will also appeal to anyone with limited mathematical training who desires to sharpen his intuitive appreciation of statistics in decision making. The elementary treatment of material would allow its use as a background text for an in-company training program designed to broaden the understanding of statistical principles.

SERVOMECHANISM FUNDAMENTALS

By Ben Zeines; 257 pages, 6 by 9¼ inches, published by McGraw-Hill Book Co. Inc., New York; available from AUTOMATION; *$5.50 postpaid.*

A brief, elementary treatment of servo systems written especially for the technician. Specific systems or equipment are not examined in detail. Assuming that the reader will primarily be concerned with proper operation and maintenance of servo systems, the author has stressed fundamentals in order to develop understanding of all types of servo equipment which might be encountered in the field.

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Circle 762 on Page 19

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We seek a qualified engineer to assume full responsibility for design and development of standard machine components and special machinery, particularly in assembly field. Must be creative, experienced, and able to work with minimum supervision.

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Submit resume leading to personal interview. Battle Creek Packaging Machines, Inc., Battle Creek, Michigan.

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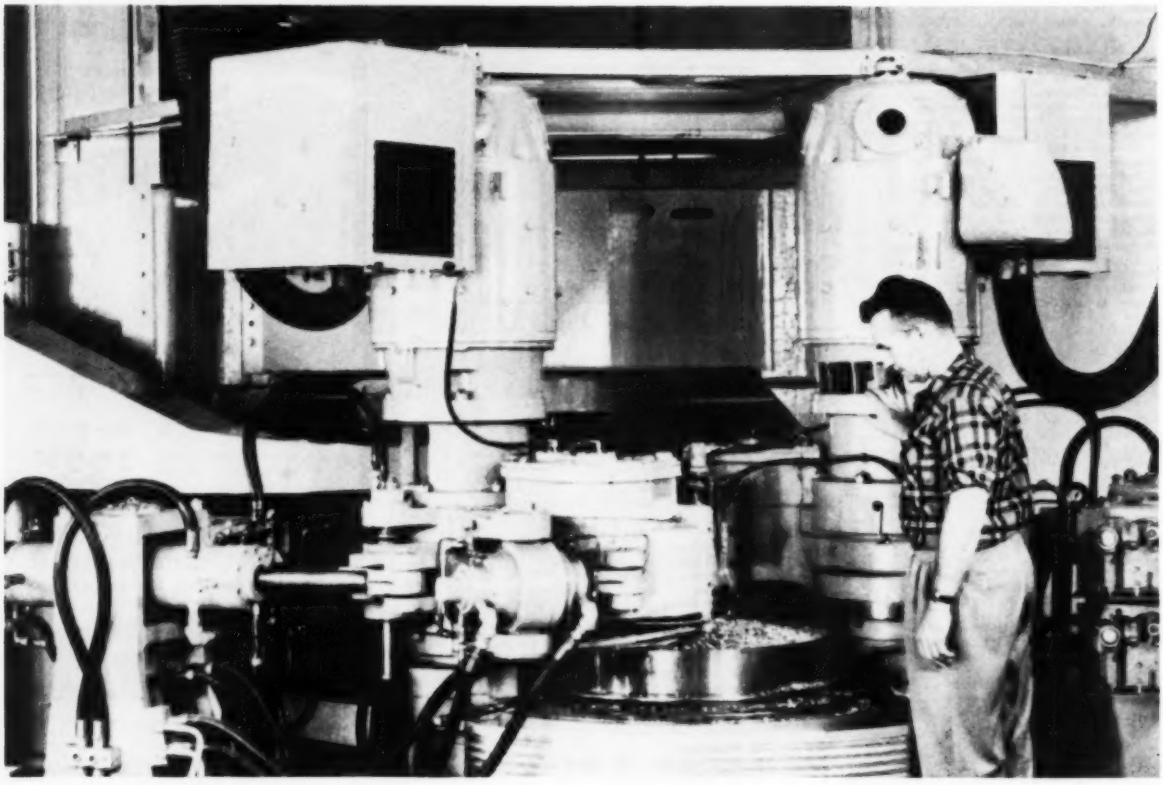

3 dimensional milling machine powered by RELIANCE V★S DRIVE

The Ames Aeronautical laboratory at Moffett Field, California, uses this milling machine capable of producing a complex curvature such as airfoil model in one milling operation. The machine weighs 150 tons, and was designed and built by Danly Machine Specialties, Inc.

A Reliance V★S Drive was specified by Danly to power this new mill because of its ability to perform accurately, even under adverse conditions.

Working at tolerances of better than plus or minus 0.004 in., the Reliance V★S Drive must provide variable speeds between the milling cutters which shape the blank and the pattern table where the pattern is mounted.

Completely powered by a Reliance V★S, this new machine can sculpture in metal a complex airfoil shape at a fraction of the time and cost required to produce a similar shape by conventional machine tool and handwork methods.

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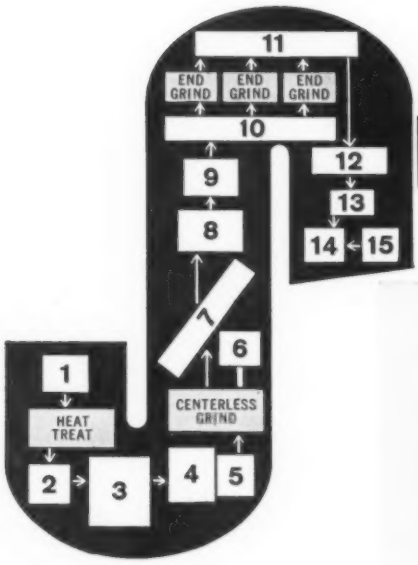

Flow diagram showing typical applications of

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2. RCA Elevating Orienting Feeder
3. RCA Automatic High-Speed Hardness Testing Machine
4. RCA Floor Feeder
5. RCA Rotary Hopper
6. RCA Grinder Control
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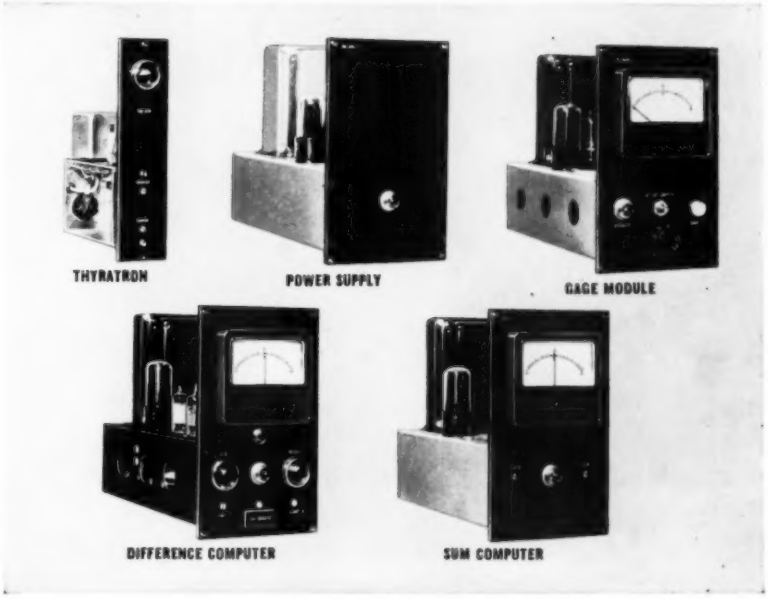
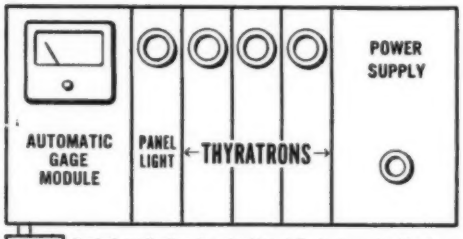


With these standard precision-engineered electronic modules, now available from RCA, you can build automatic systems to meet your exact gaging needs.

Easily assembled, such systems offer high reliability, 100% repeatability, and unusual accuracy. These same modules are now being incorporated in numerous RCA automation systems in use throughout the metal working industry, in such applications as automatic grinding controls, hardness testing, and the inspection of pistons, pins, ball and roller bearings.



Typical application for checking O.D. in four classifications. More complex systems can be assembled by incorporating additional modules such as a DC-7 Difference Computer and Sum Computer.

AGMC GAGE MODULE (includes gage head and coaxial cable): transforms the electronic changes caused by displacement of a gage tip into a directly useable signal requiring no amplification.

ATM THYRATRON: energized by AGMC output, provides a limit signal used directly for actuating segregating gates and marking or stamping devices.

APS POWER SUPPLY: feeds up to five thyratron modules.

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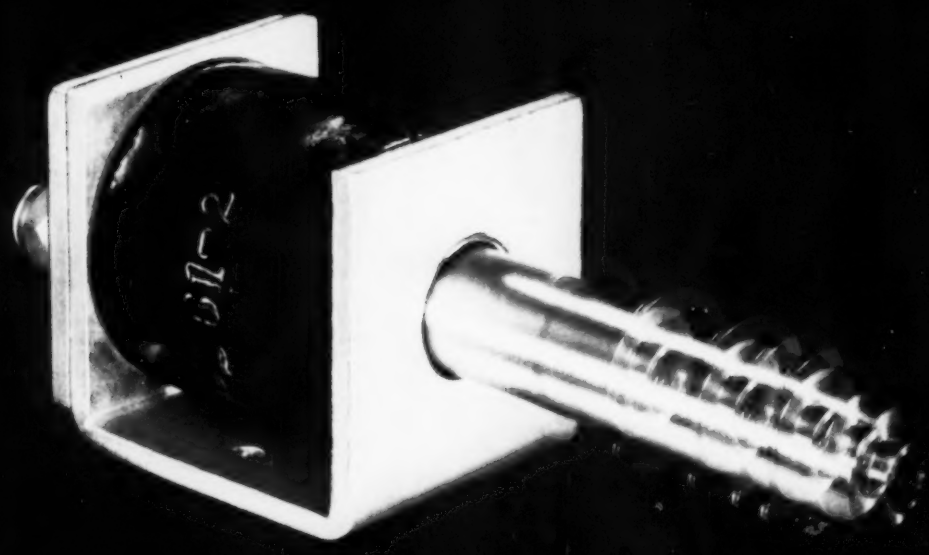

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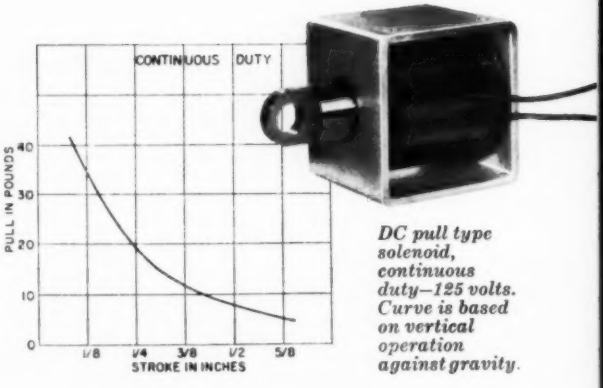

DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

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